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ENERGY: STATUS AND DEVELOPMENT--44

TARIM BASIN OIL DEVELOPMENT STUDIED

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CHINA REPORT  
ECONOMIC AFFAIRS  
ENERGY: STATUS AND DEVELOPMENT--44  
TARIM BASIN OIL DEVELOPMENT STUDIED

[Selected articles from a special issue of SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY], Vol 6, Jun 1985, subtitled "PROSPECTS FOR TARIM BASIN OIL AND GAS"]

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## FOREWORD

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6,  
SPECIAL ISSUE, Jun 85 p 1

### [Summary] Foreword

On 22 September 1984, on the eve of the 35th anniversary of the founding of the Peoples Republic of China, a prolific hydrocarbon current was discovered in the zone of weathering of Paleozoic carbonate at depths of 5,363-5,391 meters in well Shacan-2, which is located on the Yakela structure of the North Tarim uplift of the Tarim Basin. The well was drilled by drilling team 6008 of the Xibei Bureau of Petroleum Geology, Ministry of Geology and Mineral Resources. Initial daily oil and gas production is estimated to be 1,000m<sup>3</sup> and 2,000,000m<sup>3</sup> respectively. Another great discovery in the history of China's oil and gas exploration, it is of profound significance for developing the Tarim Basin, constructing Northwest China, and promoting China's construction of the "four modernizations."

The Shacan-2 strike indicates that:

- 1) The Tarim Basin, with a total area of 560,000 km<sup>2</sup> and a sedimentary thickness of 15,000 meters, contains not only Meso-Cenozoic sediments with abundant oil and gas accumulations (e.g., Yiqikelike oil field, discovered in 1958, and Kokyar oil field, discovered in 1977), but also Paleozoic platform formations below the sparsely populated Taklimakan desert and its contiguous zones.
- 2) There are abundant hydrocarbon resources in China's Paleozoic marine sediments with an area of 2,500,000 km<sup>2</sup>. Even though the sediments attain a depth of up to about 5,400 meters, high quality crude oil can be found there. The capacity for production of the Paleozoic marine sediments will be comparable to or exceed the current yearly rate of 100 million tons of oil in the Mezo-Cenozoic continental sediments. It will provide an important material base for the goal of quadrupling the output value of China's national economy by 2000.
3. The second round of oil prospecting in China has broad prospects. Its strategic goal, characterized by the "four new's" (new exploration formations, new oil and gas pool types, new prospecting areas, and new exploration depths) is very farsighted.

The geological research work, especially the exploration of the Tarim Basin, is insufficient owing to several reasons. Rapid exploration of its huge potential requires specialists, scholars, engineers, and economists to formulate a master plan. It is for this reason that we have organized this material on the hydrocarbon potential of the Tarim Basin.

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## OIL AND GAS

### TARIM BASIN COULD BE MAJOR FACTOR IN FUTURE ENERGY PLANNING

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6, SPECIAL ISSUE, Jun 85 pp 7-8

[Article by Li Desheng [2621 1795 3932], chief geologist, Petroleum Exploration and Development Research Institute of the Ministry of Petroleum Industry: "China Certain To Have Several Substantial Increases in Oil and Gas Reserves and Output Before the Year 2000"]

[Text]

I

China has many geological factors that are conducive to the formation of giant, high-output oil fields. This has been proven through practice in exploration and acknowledged by petroleum geologists.

Since Liberation, regional comprehensive exploration methods and cooperation by all departments have been used to discover petroliferous regions in the Songliao Basin. The giant Daqing oil field has been developing smoothly for 24 years. Annual crude oil output has exceeded 50 million tons for 8 years now, and the peak oil output period may extend for a few more years. Next, with the cooperation of all departments, the petroliferous region in the Bohai Gulf coastal basin was discovered and a series of oil fields have been developed at Shengli, Dagang, Liaocheng, Huabei [north China], Zhongyuan and other places. Annual oil output from petroliferous regions in the Bohai Gulf now has reached 47 million tons, and there is potential for expansion of oil and gas output. Discovered in the 1950's, the Karamay oil field has been explored more extensively and wells have been drilled deeper. Many Mesozoic and upper Paleozoic petroliferous reservoir strata have been discovered in the Karamay-Urumqi fracture zone that extends for 250 kilometers from east to west. This has multiplied proven reserves by many times. The completion of seismic surveys and exploration throughout the basin and verification of the Junggar Basin provide hope that an important petroliferous region can be built in western China. The Sichuan Basin historically has been China's main natural gas producing area and it now actively is expanding natural gas resources and building new gas fields. Furthermore, progress based on new technologies has been made in the Erlian, Beibu Wan, Subei, Jianghan, Nanyang, Ordos, Jiuquan, Qaidam, and other basins and the results of exploration will be expanded gradually.

Several rather substantial increases will occur in China's oil and gas reserves and output before the year 2000. Current achievements in geological, geophysical exploration and exploratory drilling work provide hope for the future that fairly large oil- and gas-producing regions will be found in the Zhujiangkou, Yingge Hai, Donghai, and Tarim Basins.

## II

The Tarim Basin covers an area of 560,000 square kilometers and is a compound basin that is located in the two large collision compression zones at Tian Shan and Kunlun Shan. The crust is 45 to 50 kilometers thick. The central part of the basin is an ancient nuclear area that was formed during the Archaeozoic and Protozeroic eras. It is one of the three ancient landmasses (Zhongchao, Yangzi, and Tarim) that form the Chinese platform. It has 5- to 8-kilometer-thick Paleozoic, Mesozoic, and Cenozoic capping strata. The northern margin of the basin is an overthrust fault nappe lying south of Tian Shan that is a compressive cap on top of the northern flank of the Kuqa premontane depression. The depression contains Mesozoic and Cenozoic sediments 8 to 11 kilometers thick and has structural traps arranged in rows. The southern margin is an overthrust fault nappe lying north of Kunlun Shan that is a compressive cap on the southern flank of the Kashi-Yecheng premontane depression. The depression contains Mesozoic and Cenozoic sediments 8 to 13 kilometers thick and also has structural traps arranged in rows.

The Paleozoic in the Tarim Basin consists of platform sediments. The Cambrian and Ordovician are mainly carbonatite sediments. The upper Ordovician system in the Kalpin region is mainly dark shale. The Silurian is a set of shallow sea-littoral facies gray-green clastic rock. The Tekiliqtag region is Devonian marine facies sediments. The Carboniferous system is thicker in the west and thinner in the east, and it also is marine facies sediments. Existing information indicates that the Paleozoic is one of the primary oil generating and reservoiring rock systems in the Tarim Basin. The basin underwent several periods of structural activity after the Hercynian era. Basement fractures occurred in two groups with NE and NW orientations. Block faulting activity caused the formation of normal alternating uplifts and depressions in the basin. The Jurassic era was a segmented fault subsidence-sag basin that formed sedimentary centers at east Tarim, Kuqa, and Kashi. The southwestern [Yecheng] depression was a bay during the late Cretaceous to early Tertiary and the seawater extended eastward from Tajik and Fergana to cover the Tarim region and formed a set of shallow sea and lagoonal facies sediments. The sea regressed gradually during the Oligocene. Intense uplifting and overthrust at Tian Shan and Kunlun Shan during the late Tertiary and Pleistocene caused enormously thick molasse accumulations to form in the two southern and northern premontane depressions. The basin has polycyclic oil generation, reservoiring, capping and formation combinations. They are the marine facies Paleozoic, lake facies Jurassic and mainly continental facies Tertiary systems.

### III

Exploratory drilling for petroleum in the Tarim Basin began in 1958. Geological and geophysical prospecting and survey work was followed by the discovery and development of the Yiqikelike oil pool capped by Jurassic sandstone strata during exploratory drilling in the Kuqa depression. Petroleum surveys and exploration also were undertaken in 1977 in the horseshoe-shaped region in the western part of the basin. The Kekyar high-output condensate oil and gas field was discovered during exploratory drilling in the Yecheng [southwestern] depression and it will be developed. The capping strata are composed of Mesozoic sandstone. In 1984, a blowout occurred at the Shacan-2 well in the Yakela structure in the northern Tarim [xayar] uplift after boring through Ordovician (?) dolomite, and high output oil and gas flows were obtained. This well was drilled through the unconformity at the bottom of the Mesozoic and into the Ordovician (?) at a depth of 5,335.5 meters. The well was destroyed by a blowout at a depth of 5,391 meters. Seismic profiles indicate that the area above the unconformity is a Mesozoic-Cenozoic anticlinal structure. The Yakela structure covers an area of 1,500 square kilometers and is composed of four high points. The Shacan-2 well is located at high point No 1 at the western end. The Paleozoic below the unconformity is a southward-sloping monocline. The Paleozoic assumes a wedge shape that things and disappears moving from the Manjiaer depression toward the northern Tarim uplift. For this reason, the oil and gas pool encountered at the Shacan-2 well may be a compound trap that is controlled by structural and stratigraphic factors.

### IV

Based on seismic reflection data for a large cross-section across the huge Taklimakan desert, the eastern part of the Tarim Basin is a depression that is primarily Paleozoic strata. A central uplift zone with an east-west orientation also appeared to the south of the northern Tarim uplift and the Mesozoic is missing above it. The Tertiary unconformity caps the large Paleozoic anticline and forms a favorable trap. To the east of the northern Tarim uplift is the Konqi He slope. The Paleozoic is buried at fairly shallow depths and also has a group of local traps. All of these regions have rather great exploration prospects.

Comprehensive geological research also should be strengthened in the horse-shoe-shaped region (including the Kuqa depression, the Kalping-Bachu uplift, the southwestern slope, and the Kashi-Yecheng depression) where seismic surveys have been completed and where a certain degree of pre-exploration work has been done. Develop multiple target strata exploration and use already understood geological, geophysical prospecting and exploratory drilling results to formulate comprehensive deployment plans for favorable structural zones and local traps. Drill several parameter wells in an unbroken line each year and derive comprehensive and accurate data to complete the dual tasks of geological and preliminary exploration.

The Tarim Basin adjoins the Soviet Union's Central Asian oil and gas region and has a geological background for finding large oil and gas pools. We

must focus on high precision seismic exploration for intensive development of comprehensive geological research and adopt advanced drilling and measurement technologies to deploy a group of pre-exploration wells with the Paleozoic era as the target strata (while also prospecting in the Mesozoic and Cenozoic eras) to gain an understanding of the distributional regularities of oil and gas pools.

We should work to complete seismic sampling work for the Yakela structural zone, and we especially should determine the occurrence of Paleozoic reservoir-ing strata below the unconformity and the shapes of structures. Deploy a group of sample prospecting evaluation wells to determine the petroliferous area and reserves of this large structural zone, and clarify the categories of oil and gas pools and driving mechanisms. Integration of surveys and sample surveys in this manner and integration of the discovery of new oil pools with the proving of the reserves in several large and medium sized oil and gas pools will provide a reliable resource foundation for the state to consider in development and construction. This region has a large desert cap and a sparse population. Communications, logistics, and supply conditions are extremely difficult and we must organize and use capital, technology, and personnel from all areas to speed up the exploration work.

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## OIL AND GAS

### DATA FROM SHACAN-2 STRIKE ANSWER MANY QUESTIONS

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6, SPECIAL ISSUE, Jun 85 pp 8-11

[Article by Guan Shizong [7070 1102 5115], member of the Academic Departments Committee, Chinese Academy of Sciences, and senior engineer, Ministry of Geology and Mineral Resources: "Shacan-2 Gusher Is a Prelude"]

[Text] The first eruption of oil and gas at the Shacan-2 well occurred below 5,362 meters in the weathered top surface strata of the "Ordovician system" with high output and high pressure. The eruption continued for more than a month without letup, which proves that there are rich oil resources and favorable traps. There are different interpretations and viewpoints, however. Early reports indicated that it was a large buried hill oil and gas reservoir and subsequent reports felt that the oil sources may have come mainly from the Cambrian and Ordovician systems, but they did not eliminate the possibility that the source could be the Carboniferous-Permian and Triassic-Jurassic systems. Eventually, it was stated that the oil source came from the Triassic-Jurassic systems and that within these systems a Tertiary high-pressure water layer cap caused the oil and gas to migrate downward into Cambrian-Ordovician weathered dolomite reservoir strata.

There are varied explanations and a lack of agreement. It seems that further discussion of the oil source strata and type of oil pool and an evaluation of prospects are necessary.

#### I. The Awat-Manjiaer Depression

Known originally as the eastern Tarim depression, the 160,000-square kilometer Awat-Manjiaer depression was a primary depression during the developmental stages of the Tarim platform. It was a region of Paleozoic marine regression during the later period of Hercynian activity, which also was the late period of platform development that led to the development of a continental facies basin. In an overall geographical sense, the Awat-Manjiaer depression begins in the west at Awat and extends east to Konqi He, north to the Kuqa depression and south to the Ruoqiang depression. In strict geological terms, however, the continental facies sediments of the depression should be considered Mesozoic and Cenozoic and should not include the Paleozoic.

Its structural position is at the margin of a trench-platform transition zone. Its developmental history is manifested as a graded and non-conformity situation of subsidence and sedimentation centers. Gravitational abnormality maps of the eastern Tarim region show either local abnormalities with a NW and east-west orientation or they exhibit folding of the Paleozoic, especially the early Paleozoic capping strata, and uplifts of the ancient basement. They sometimes are identical to the orientation of surrounding geological components.

Moreover, we encountered the Jurassic system during drilling only in the Kuqa premontane depression and at Konqi He, Tarim He, and Tikanlik (part of the Kuruktag premontane depression), and it was discovered that it is a cap directly above the lower Paleozoic and even older rock strata. Moreover, only late Triassic coal-bearing strata (felt to be T3-J1) were discovered south of the "Xayar uplift" and in the region west of a line from Luntai to the Lun-1 well (including the Shacan-2 well and the Yuecan-1 well). We can conjecture from this that the so-called eastern Tarim depression is unrelated to the oil generating and reservoiring Jurassic. It is merely a non-representative Jurassic oil-generating depression of the Aksu-Manjiaer depression. Moving from east to west, the strata encountered below Cenozoic strata in the eastern Tarim area were the lower Paleozoic Silurian and Ordovician systems and the upper Paleozoic Carboniferous and Permian systems, indicating that the strata are different below the denuded Paleozoic surface. The Mesozoic strata (mainly the upper Triassic system) above the denuded surface are not thick. For this reason, it is felt that, with the exception of the Kuqa premontane, Kuruktag, and Ruqiang premontane depressions, no Mesozoic Manjiaer depression (mainly the Jurassic) existed in the eastern Tarim region.

## II. Some Views on the Existence of the Eastern Tarim Synclinorium

The central uplift in the Tarim Basin (the Bachu uplift) slopes downward in a southeasterly direction toward the eastern part of the basin. This means that the basement in the eastern Tarim region is buried at great depths. Seismic measurement lines moving from south to north indicate that the sediments in the eastern Tarim region may be several 10,000 meters thick. Seismic wave group analysis indicates that the Paleozoic strata, especially the early Paleozoic, are enormously thick while the Mesozoic and Cenozoic both are wedge-shaped and complementary. They are much thinner than the Paleozoic strata. There is no Mesozoic or Cenozoic depression in the Majiaer depression and there is no absolute indication of an enormous Paleozoic depression. Instead, the late Paleozoic strata things or has been eroded away, while more of the early Paleozoic strata have been preserved. There is no obvious segmentation and deep subsidence of the eastern Tarim region within the Tarim platform, so its platform facies group sediments should be relatively even in thickness. Geophysical exploration data indicate that the basement is buried deeply and that the capping strata have thick wave groups. Drilling has revealed that more of the early Paleozoic strata have been preserved below the Mesozoic and Cenozoic eras. This also shows that the "Majiaer depression" is not a deep Paleozoic depression but instead that the series is a synclinorium caused by the final episode of the Hercynian. In the area affected by the

Indo-Sinian movement in the Tian Shan and Kuruktag premontane zones and in the region near the "Zayar uplift," late Triassic strata stopped accumulating and are preserved on a foundation of Hercynian folded uplifts and depressions, and structural patterns have stabilized gradually since the late Indo-Sinian period. The existence of the eastern Tarim synclinorium is related to the Shacan-2 gusher.

### III. Paleogeography of the Paleozoic Lithofacies in Eastern Tarim

Based on the theory that the oil and gas source of the Shacan-2 well came from the Paleozoic, it is necessary to dissect the paleogeography of the Paleozoic lithofacies in the eastern Tarim area to estimate its prospects. Lower Paleozoic outcrops are widely distributed in eastern Tarim to the east of Kalpin and Bachu and at the margin of the southern Tian Shan and extending to Kuruktag Shan. The upper Paleozoic is less common in the eastern part but was encountered more during drilling at Bachu, Kalpin and in the concealed central uplift zone. The Paleozoic is mainly carbonate rock interbedded with dark argillaceous rock and is excellent oil generating strata. Oil and gas occurrences have been found not only at the Shacan-2 well but also at the surface and in other wells. As for the distributional pattern of marine facies throughout the early Paleozoic, marine facies sediments in the eastern Tarim region are a combination of multiple troughs surrounding a platform in that the ancient Tarim landmass was surrounded by the ancient Chinese sea during the late Protozeroic and early Paleozoic. It was roughly the same as the modern Tarim He basin region and all of it was a platform facies region with a surrounding trough basin facies region that generally is favorable to oil generation. During the late Paleozoic, Konqi Island, Qiemo Island, the Xinqing Island landmass, Bachu Island, Yecheng Island and other terrigenous supply regions appeared within the Tarim Basin, while Tarim itself remained platform facies sediments. A long period of marine transgression occurred in the region surrounding Konqi Island and Qiemo Island in the eastern Tarim region during the Carboniferous and Permian eras, and transitional facies developed that were favorable to oil generation. However, Permian and early Carboniferous strata, which are among the primary strata positions in Tarim, now may have been preserved only to the west of a line running from Luntai to Minfeng. This means that it is not easy to have high prospects for Carboniferous-Permian oil generating strata in the eastern part of the Tarim Basin. Combinations of a platform surrounded by multiple troughs or sea-land transitional zones may develop in a narrow facies zone that is near a platform margin or even extending into a platform, and it also is possible that carbonate rock high-energy beach facies bodies developed, all of which could have formed excellent reservoir strata. Argillaceous rock is distributed widely in the eastern Tarim region, and the Mesozoic argillaceous rock to the north and south of the "Zayar uplift" are excellent regional capping strata. The Shacan-2 gusher indicates that there are rather favorable generation, reservoiring and capping conditions in the lower Paleozoic in the eastern Tarim region.

### IV. Structural Patterns and Types of Oil and Gas Pools

The zone of weakened or bent seismic wave groups at the northern margin of the eastern Tarim region, at the "Xayar uplift" and running in a SE-NW

direction at Luntai quite possibly may be the southern and western boundaries of the Jurassic Kuqa and Kuruktag premontane depressions, and it has been inferred that this uplift zone of the last episode of Indo-Sinian activity has no or very little Jurassic overlap. Just the opposite of the buried hills viewpoint, the "Xayar uplift," the Yakela structure above it and the distribution of certain high points may mean that the concealed Hercynian NW-oriented uplifted-folded zone has overlapped and transformed by the east-west oriented Indo-Sinian uplifted-folded zone. For this reason, it cannot be considered a simple fault block or buried hill structure, nor can it be considered a fault block or buried hill oil and gas pool.

If the "Xayar uplift" overlaps the Indo-Sinian uplift on top of the Hercynian uplift folded zone, then there is great hope that a normally-oriented structure that has been overlapped or transformed in this way may be found in favorable early Paleozoic oil generation and reservoiring lithofacies zones, which also could be oil and gas pools in sheltered structures of the lower Paleozoic era. The high-pressure, high-output strata at the Shacan-2 well is an excellent example.

#### V. The Oil Source of the Shacan-2 Well in Light of Oil and Gas Occurrences in Tarim

The Tarim Basin has many epochs of oil generation, many categories of oil reservoirs and many types of entrapment combinations. Oil and gas occurrences and industrial oil and gas flows already have been discovered at more than 100 sites in the strata of each era since the Carboniferous. The main ones are: 1) The Wuqia lower Tertiary oil sands; 2) the Yiqikelike industrial oil flow Jurassic strata at Kuqa; 3) the Qiulitage Triassic oil seepages at Kuqa; 4) the Qiemo Mesozoic oil sands; 5) the Kekyar Miocene high pressure high output oil and gas strata at Hecheng and others. All of these oil and gas seepages (flows) came from the Carboniferous-lower Permian, upper Permian, Triassic, Jurassic, upper Cretaceous-lower Tertiary and other sets of oil generating rock systems. The discovery of Miocene oil and gas flows at Kekyar and the Miocene oil sands encountered during the drilling of the Shacan-2 well indicate that we should not eliminate completely the possibility of Miocene oil generation in the Tarim region. I feel, however, that the Shacan-2 gusher is related to sheltered structures and oil reservoiring in weathered porous strata, and that the oil source was the lower Paleozoic itself. A second examination of the Kekyar oil source is at least in order. The success of the Shacan-2 well is the first discovery of industrial oil and gas flows in the lower Paleozoic strata position within the Tarim region and even within China. Moreover, it is the first discovery of marine facies industrial oil and gas flows in China and is of great significance for exploration and development of marine facies Paleozoic oil and gas fields in China.

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## OIL AND GAS

### NEW FINDINGS REQUIRE RETHINKING OF EXPLORATION POLICY

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese No 6, SPECIAL ISSUE, Jun 85 pp 12-14

[Article by Shi Xunzhi [0670 6064 4249], chief geologist, Science and Technology Department, Ministry of Petroleum Industry: "Research on Policy-making for Large-Scale Exploration of the Tarim Basin"]

[Text] The first oil pool formed in Jurassic sandstone was discovered at Yiqikeli in the Kuqa depression at the northern margin of the Tarim Basin, proving that it is a petroliferous basin. During the late 1970's, the Kekyar oil and gas field, formed in Tertiary sandstone, was discovered in the southwestern depression. In the early 1980's, a high-output oil and gas well, the Shacan-2 well, was drilled in the northern Tarim uplift in the northern part of the basin. These three important discoveries prove not only that oil was produced at the margin of the basin but also that oil was produced within the basin, that oil was produced not only in Mesozoic and Cenozoic strata but also in Paleozoic strata, that not only is there oil but also that there is gas, and that not only was there moderate and low output but also that there is high output. It has become quite clear that there are great prospects for the Tarim Basin to become a large petroliferous region, but the question of how to accelerate further exploration for its oil and gas and how to make even greater breakthroughs requires us to provide a more intensive understanding for making new policy decisions.

Research on these new policy decisions requires answers with fairly good foundations concerning the actual amount of reserves in the Tarim Basin, the output that could be obtained, the pace of development that can be achieved and other questions. This requires us to do further technical and economic analysis, but the most basic is geological analysis and there should be a comprehensive evaluation of the basin as a whole. Research should focus on the following questions to attain this goal.

#### I. Evaluation of Oil Generation in the Strata of Each Era

Evaluation of oil generation involves an examination of the basin's total oil and gas reserves and resources structures (oil:gas: condensate). This is especially true in light of the fact that the basin has two oil-generating systems--continental facies and marine facies--and that they have different

characteristics and regularities. We can infer from general regularities in eastern China that the Mesozoic and Cenozoic continental facies sediments in the northern Tarim depression, for example, are an oil-generating depression. Is the northern Tarim depression truly an oil-generating region with Paleozoic marine facies sediments, however? This is not certain. The crust in the Tarim Basin is thicker than in eastern China, the mantle uplifts are not located exactly in the center of the basin and the temperature gradient is lower relative to the eastern regions. Current information, however, indicates that the  $R_o$  of the Carboniferous system exceeds 1.3 percent, which is a state of over-maturity. Is this a peculiar local phenomenon or is it representative of the overall situation in the entire basin, particularly in the Carboniferous system and the lower Palozoic below it in the ventral part of the basin? The Kekyar oil field and the Shacan-2 well are located at the south and north, respectively, but both of them have high gas and condensate contents. This presents us with the question of natural gas as a proportion of total resources in the basin. This series of questions requires us to study the oil generation conditions of the Tarim Basin. We cannot merely use the concept of continental facies and not use the concept of marine facies, and we cannot merely use the concept of oil and not use the concept of gas, nor can we use data for the margins of the basin and not use data on the ventral part of the basin.

## II. Evaluation of Paleozoic Marine Facies Strata

Marine facies sediments are fairly developed in the Tarim Basin, with sediments from the Sinian through early Permian periods. The lower Paleozoic basin connected the southern and northern China seas and the entire period basically was a rather stable environment. There were accumulations in each period and most of the region was a shallow sea.

It now is buried at substantial depths and has a rather low temperature gradient. Compared with southern China, the south had a high degree of thermal metamorphism and surface outcrops appear over most of the region, so preservation conditions were poor. Compared with northern China, the north lacks the Silurian and Devonian systems, and the late Paleozoic is continental facies sediments; those in the northeast already have been metamorphized. There are, therefore, superior conditions here for finding marine facies oil and gas pools and it is possible that it will become the first marine facies oil and gas region on the continent in China. Furthermore, the late Cretaceous to Eocene periods also have marine facies sediments. Although they are distributed mainly in the southwestern part of the basin, there is a rather large sea-land transitional zone. This is quite different from other Mesozoic and Cenozoic continental facies sedimentary basins. For this reason, when evaluating the oil and gas resources of the basin, we cannot sweepingly use only continental facies oil and gas formation and distributional regularities to understand the distribution of oil and gas in marine facies sediments, nor can we simply apply wholesale the experiences in oil and gas exploration in the continental facies basins of eastern China to deal with exploration of marine facies oil and gas pools at Tarim.

### III. Demarcation of the Sedimentary Environments and Sedimentary Facies of Each Era

The Tarim Basin had had rather frequent sea-land changes and many classes of sedimentation. Marine transgression occurred four times from the Sinian to the Carboniferous and there was an additional instance of marine transgression from the late Creaceous to Eocene. The basin contains at least five periods when sea-land dividing lines or boundaries between landmasses and transitional zones were in existence. The basin is high in the east and low in the west. Multiple instances of overlap occurred throughout the entire developmental process through geological history. These ancient land-sea boundary lines, positions of coasts, lines of regional lithologic transition, the distribution of facies regions and facies zones and other questions are not clearly understood at present. The greatest part of our understanding of sedimentary environments and sedimentary facies in the basin is based only on inference from local data from the margins of the basin. This is especially true of the vast middle part of the basin, for which there is almost no data. We should, therefore, utilize regional seismic profiles in combination with data from parameter wells to study regional seismic stratigraphy and gain an understanding of the sedimentary facies for each period throughout the entire basin and their lithologic combinations. This is an important foundation for selection of key realms and regions of exploration.

### IV. Research on Evaluation of Reservoir Strata

Determination of high-output rich accumulations is the key to understanding reservoir strata, but this point often is forgotten.

There are almost no porous reservoir strata in marine facies carbonatite strata in southern China. Almost all are fissured reservoir strata or fissured-porous reservoir strata that are primarily fissured. Conditions in the Tarim Basin seem better. Most periods are shallow sea platform facies, and many accumulations formed under high energy environments. The existence of reefs is inferred. Sedimentary bodies with the characteristics of reefs already have been found on the north slope of the southwestern depression. Do marine facies sediments in the Tarim Basin have the conditions for extremely high output? This is a question that requires understanding. A comprehensive evaluation of marine facies and continental facies sandstone reservoir strata within the basin is necessary. The reservoir strata in the Yiqikelike oil pool are lenticular sandstone, but sandstone strata several hundred meters thick can be found there as well. Large anticlinal uplifts are found in the ventral part of the basin, but the question of the physical qualities of oil reservoiring obviously cannot be compared with the physical qualities of shallow strata at the margins. This requires that parameter wells be drilled to understand the condition of the reservoir strata.

### V. Research on Structures in the Basin

The Tarim Basin is a passive basin and water level forces played a major role. This obviously is different from the sedimentary basins in eastern China. There are large-scale overthrust structures around the Tarim Basin and pre-montane depressions developed at the margins. The most recent seismic data

indicates that large uplifts (anticlines) and downwarps (synclines) exist in the central part of the basin and that Mesozoic and Cenozoic sediments thicken obviously move from the uplifts toward the downwarps, but the phenomenon of increased thickness is not apparent in Paleozoic sediments. The phenomenon of a lack of concordance between some upper and lower structures is found at the margins of the basin, in the Kuqa depression for example, and the surface layers are comb-shaped linear anticlines, but the concealed structures under their synclines are the tops of rather broad anticlines. This requires systematic research on the distribution of the uplifts and downwarps in the basin, on the relationship between various structural strata and the structures above and below, and on the development and distribution of fracturing.

To solve these problems, we must coordinate the necessary exploration work, especially large regional seismic profiles on the overall layout of the basin as a whole, and select a group of favorable local structures for sample surveys. Drill one or two parameter wells in different sedimentary and structural regions and strive to reach the basement as quickly as possible. Intermediate measurements should be taken for all reservoir strata at each parameter well, and there should be analysis of the sedimentary environments and facies of the strata at each well and evaluation of oil generation and reservoir strata. With these data, we can do comprehensive research on problems in the five areas above and make a comprehensive evaluation of the basin.

The Tarim Basin is a large petrolierous basin and requires large-scale exploration activities. The areas that already have produced oil may not be the best places, however. Of course, the development of exploration in known petrolierous zones can permit oil and gas pools to be found rather quickly and also can assist us in gaining an understanding of the regularities of oil and gas distributions. The most urgent work at the present time, however, is to begin with the overall situation in exploration of the basin and to organize and carry out research on policy-making for large-scale exploration in order to suggest the most favorable spheres and regions of exploration to permit wide-scale drilling at the earliest possible date.

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## OIL AND GAS

### URGENCY OF EXPLORATION IN NORTH TARIM BASIN underscored

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6, SPECIAL ISSUE, Jun 85 pp 15-16

[Article by Huang Xude [7806 4872 1795], senior geologist, Computing Center of the Ministry of Geology and Mineral Resources: "The Northern Tarim Uplift Is a Top Priority"]

[Text] The oil pillar and flame at the Shacan-2 well awakened a vast land that had lain dormant for billions of years and the underground oil and gas began renewed migration, seeking a new equilibrium of underground pressure. Those engaged in the struggle for energy resources on the surface also were shaken and obtained enormous satisfaction. They have begun to gather forces to provide even more oil and gas and create wealth for the people. Guesses, inferences, and expectations may become reality: "Tarim is a cornucopia that can double petroleum output in China." The movement from concept to reality is a difficult process that requires us to determine the layout of oil pools and to invest large amounts of equipment, iron and steel, cement, capital, and manpower. Our resolution can be strong only if we understand the situation. I feel that the urgent tasks in the northern Tarim [Xayar] uplift are intensive and comprehensive development of geophysical work matched with a group of test wells to gain a better understanding of certain basic geological characteristics and locate a large group of various types of traps, to evaluate each and select them for drilling, and to improve the percentage of hits to facilitate continual expansions of strategic successes on the basis of preliminary victories and create a favorable situation for development.

The effort of comrades before us, especially those who have gone to Xinjiang since 1978 or since the second round of petroleum surveys in 1982, have provided quite a bit of knowledge concerning the basic geological characteristics of the northern Tarim uplift (also called the Xayar uplift), a secondary structural component in the Tarim Basin. It is a fault uplift zone surrounded by downwarps that was formed over a long period. It covers an area of several 10,000 square kilometers and is a directional region for oil and gas migration. It has three most favorable oil generating strata systems (Ordovician, Carboniferous, and Jurassic systems) as well as several favorable generation, reservoir, and capping combinations. Local structural zones, mainly thrust faults, developed in the fault-uplift zone. These important

geological achievements were the basis for the important breakthrough at the Shacan-2 well.

I feel that a further clarification of some basic geological questions is needed before the conditions can be prepared for a comprehensive breakthrough.

The first concerns the conditions in the Ordovician sea basin, the Carboniferous sea basin and the Jurassic continental basin. Fairly accurate lithofacies and paleogeographic maps of these basins should be compiled to clarify the layout and history of locational changes in the northern Tarim uplift during these three periods and to clarify the distribution of favorable lithofacies zones in the northern Tarim uplift and the formation history of local structures.

Second, we should obtain data concerning ancient temperature gradients and the absolute age of strata. Only then will it be possible to calculate reliably the degree of maturity of oil generating rock and the peak period of oil generation, and to plot a contour map of degrees of maturity for each oil generating stratum in the northern Tarim uplift to be matched with charts of the history of uplifting, subsidence and translocation and the formation history of each local structure to understand the formation conditions of oil pools in each local structural trap.

Last, we should delineate all possible structural traps and stratigraphic-lithologic traps for each period and combine them with data on the paleogeography, ancient geological history, ancient temperatures and other aspects described above to evaluate, arrange and grade each trap, calculate weathering coefficients and formulate exploratory drilling programs.

Integrate points and planes to achieve this purpose. We should complete 1:1,000,000 comprehensive regional geophysical measurements for the entire Tarim Basin. Geophysical surveys at a scale of 1:200,000 to 1:100,000 should be completed for the northern Tarim uplift, with a focus on seismic surveys. There should be a high degree of superposition with digital seismographs, conventional and special processing and comprehensive descriptions that integrate structures, strata and lithology with oil and gas. The measurement lines should cross boundaries and extend the Kuqa depression, the eastern Tarim depression and the Manjiaer depression, and there is a special need to cross the boundary of the basin for the three periods described above. This is extremely necessary when using seismic profiling to do seismic stratigraphic analysis. Based on seismic profiles for the area being surveyed, make depth contour maps and structural maps for the six standard strata and six sets of apparent thickness contour maps for each of the six sets of strata and remap the thickness of the strata. Do seismic stratigraphic analysis to formulate illustrations of seismic facies and geological facies for all of the strata and plot planar uplift and subsidence maps for the ancient sea. Use this to make lithofacies and paleogeographic maps, maps of geological development history and historical maps for the uplifts and subsidences of each set of strata. Calculate the degree of maturity and plot contour maps for degrees of maturity. Determine the optimum zones for oil generation and

reservoiring and discover various potential local traps. Carry out 1:50,000 and 1:25,000 sample surveys to determine and delineate the scope and high points of traps, determine their type and characteristics, and carry out evaluations and grading.

To achieve this we must improve the quality of seismic profiles. The focus should be on clarifying the three T<sub>4</sub>, T<sub>5</sub> and T<sub>6</sub> wave groups, improving signal to noise ratios, resolution rates and degrees of precision, improving the precision of static comparisons, clarifying fault points and fault strata combinations, clarifying the regularities of velocity changes and making good arrangements for offsets to make the best amplitude restoration profiles, theories of measurement well profiles, complex number channel analysis profiles, strata velocity profiles and hydrocarbon measurement profiles. In conjunction with this, there should be acoustic velocity measurement wells,  $\gamma$ - $\gamma$  measurement wells and seismic measurement wells for all stages of drilling. We should strengthen monitoring of static comparison data in the field and improve the precision of measurement line position observations. High quality processing and interpretation are impossible without high quality field measurements. This must be re-emphasized time and again.

Data handling depends mainly on geophysical prospecting, but interpretation of drilling points also is necessary for close integration of geophysical exploration, measurement wells, drilling and geology. Geophysical prospecting should integrate gravitational, magnetic, electrical and seismic methods and use gravitational, magnetic and electrical data to aid in research on the basement and regional structures in the basin. Geophysical workers should integrate closely with geologists when making the interpretations described above. Only through this multifaceted combination will it be possible to achieve the anticipated results. This makes it necessary to continue deploying trial exploratory drilling in prospective structures according to existing data. There is hope that these wells will produce oil once again and that utilization of these wells in combination with comprehensive geophysical exploration can be used for reliable geological interpretations to make preparations for improving the percentage of hits in future exploratory drilling. We should, therefore, feel even more confident if they produce oil once again while not losing our hope if they do not. We should derive the comprehensive geological, geophysical and measurement well data needed for parameter wells. Even greater hopes lie behind them.

The oil and gas prospects of the Tarim Basin already have been acknowledged and I feel that marine facies carbonate rock is of even greater special significance. The structures of Paleozoic carbonate rock strata in the Yangzi [platform] region are complex and many oil and gas pools have been destroyed. The technical requirements for understanding the region's complex structures are high. The degree of maturity is too high in regions with good preservation of pools, and there are many gas pools and few oil pools. Apart from that surrounding the mountain systems, the Paleozoic carbonate rock in the Tarim Basin has not been folded as intensely within the basin as in the Yangzi region (although there are very few exposures and the depth and precision of seismic profiles are insufficient. The geological history of block faulting and uplifting-subsidence of the entire region provide a basis

for this inference). Moreover, the degree of maturity of oil generation has not yet reached its peak period and it can be said that it is at its prime. In a basin of such enormous size, multiple periods of superimposition and broad folding, isn't it possible that large or even extremely large oil and gas pools might be found?

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## OIL AND GAS

### ROLE OF GEOPHYSICAL EXPLORATION IS KEY ELEMENT

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6, SPECIAL ISSUE, Jun 85 pp 17-18

[Article by Zhu Dashou [2612 1128 4849], senior engineer, Petroleum Geology and Marine Geology Bureau, Ministry of Geology and Mineral Resources: "Give Further Play to the Role of Geophysical Exploration, Strive for Even Greater Results"]

[Text] High-output oil and gas flows have been obtained in the Shacan-2 well in the northeastern part of the Tarim Basin. This is an important achievement made during the second round of oil and gas survey work, and has attracted attention in all areas and received high evaluations from many experts. With the good overall situation and in consideration of the degree of actual work in the Tarim Basin, we should speed up entry into the key breakthrough stage. A great deal of work remains to be done and the tasks we face are arduous ones. To gain an understanding of the regularities of deep structural conditions and oil and gas conditions, to motivate the whole situation by fanning out from point to area, and to use fast but effective methods, we should adhere to the principle of "having geophysical exploration go first." We must give greater play to the role of geophysical exploration, strengthen quality management and improve interpretation levels. Only in this manner will it be possible to obtain even greater oil and gas achievements. We should focus on the following problems at the present time:

#### I. Conscientious Research on the Nature of Uplifts and Their Internal Structures Is the Basis for Expanded Achievements and Concerns Our Ability to Intensify Future Work, and It Is the Key Factor that Affects Work Results

Most people feel that the Tarim Basin has undergone two major developmental periods and that it has a three-level structure. The qualities of  $T_5^0$  reflection waves show rises in unconformities and do not represent the situation in a particular structural layer. A fairly low signal-to-noise ratio shown on seismic profiles for most deep areas added to the rather large horizontal changes in velocity permitted delineation of the so-called  $T_5^0$  structure map. Generally speaking, all require improvements in work methods before they will be of real scientific significance. This means that we must focus closely on improvements in reflection quality and research on wave group characteristics below  $T_5^0$  throughout work deployments, data collection, information processing

and interpretation of results. A great deal of effort must be expended to gain an understanding of the nature of the uplifts and their internal structures. Only if this problem is solved well, will we have a scientific foundation for major breakthroughs in the future!

Nevertheless, I do not wish to demean in any fashion the results that already have been achieved. There still are rather good prospects for finding oil in the unconformity reflected by  $T_5^o$  within the Xayar uplift in the northern Tarim region. One of the major experiences in China in more than 30 years of oil and gas exploration is that more and more high output oil and gas flows are found near unconformities. The Shacan-2 well is the most recent and deepest high output well. Conscientious research on the characteristics of the  $T_5^o$  reflection plane is indispensable and of major significance for continued discovery of oil and gas pools.

## II. We Must Conscientiously Study the Newest Seismic Prospecting Achievements, Strive To Find New Types of Traps and Continue To Enrich Oil and Gas Achievements

In terms of its geodesic structural layout, the Tarim Basin was subjected to the effects of compression of the Eurasian plate and the Indian Ocean plate, and basement fault blocks play a controlling role for sedimentary capping strata. Rather complex draped folds of various shapes may exist there, and different classes of traps may have formed before and after the folding as well as during the folding process.

Generally speaking, there are many different categories of traps here that can serve as the targets of oil and gas surveys. The most recent seismic profiles provide preliminary confirmation that this expectation may be realistic. It deserves special mention that anticlinal local structures already have been located below the  $T_5^o$  unconformity and that there is an obvious occurrence of "flat spots" on one flank. It is regrettable, however, that no data was collected on the other flank of the anticline on the profile because of the difficult terrain, so we can only make inferences at the present time. Distinctions can be made only when further work is done.

Striving to raise the quality of seismic work, continually studying new seismic results and focusing on the search for new types of traps should be important technical measures for future expansion of oil and gas achievements.

## III. Do Not Forget Work Throughout the Region While Focusing on "Key Breakthroughs"

The Tarim Basin is the largest petroliferous basin in China. Nevertheless, much work has been done in petroleum surveys and prospecting in recent years and industrial oil and gas flows from different eras have been obtained at Kalpin, Yiqikelike and the Shacan-2 well, which indicates that the basin has rich oil resources and great prospects. It must be acknowledged, however, that the degree of work is low at the present time. Added to the relative complexity of natural and geological conditions in the basin, the

difficulty of the work involved need not be elaborated. It is exactly for this reason that we must not be satisfied with past achievements in our work. We must have a resolute picture of the region as a whole and overall layouts, strengthen research and grasp regularities. We must integrate current geological and geophysical surveys with prospecting work in key areas if we are to be able to reduce the number of twists and turns in our progress.

It is extremely necessary that we begin with actual conditions and speed up completion of 1:200,000 gravitational and magnetic measurements (whether aerial or surface) of the entire basin. On the basis of already completed regional seismic profiles and based on the possibility of additional regional geodesic electromagnetic profiles or large seismic profiles, integrate with gravitational and magnetic data to make quantitative interpretations of the basin's regional geological structures. In this way, there will be a more adequate foundation covering a rather wide area to select and evaluate oil and gas survey and exploration areas.

#### IV. Further Improvements in Geophysical Prospecting Achievements Require Good Basic Work

There are favorable conditions as well as complex factors involved in geophysical exploration work in the Tarim Basin. Further improvements in results require adaptation to circumstances and making full use of favorable conditions as well as conscientious analysis of the various and complex factors or errors that may influence interpretation work. In consideration of the present situation, we should make systematic measurements and accumulate the physical parameters needed for interpretation of gravitational and magnetic data, and we should understand their regularities and provide a basis for quantitative interpretation.

In the area of seismic work, it is extremely necessary to obtain rather high precision velocity data for deep areas and develop multiple close-point seismic work. This is of major significance for the geological problems mentioned above that now await solutions. In addition, we should summarize and grasp regularities in horizontal and vertical changes in velocity and whether or not they affect precision determinations of structural shapes, fault positions and depth of strata.

The basis for interpretation of seismic information is correct delineation of seismic procedures. We must make full use of the dynamic characteristics of reflection wave groups, integrate with geological data and establish regional standard profiles to aid in comparison and control. This should be fairly easy in consideration of current seismic data from the northern Tarim region and can be extended throughout the basin when conditions permit.

It should be mentioned that traces of hydrocarbon indications appear on some seismic profiles. This deserves further research, and there is hope that improvements in the degree of exploration will lead to continual improvements in the ability to interpret and discriminate.

I believe that through these additional efforts and despite the number or size of future difficulties, the Tarim Basin eventually is certain to become one of China's most important oil and gas resource base areas.

## OIL AND GAS

### GOOD PROSPECTS FOR OIL, GAS EXPECTED IN TARIM'S DEEP STRATA

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6, SPECIAL ISSUE, Jun 85 pp 24-25

[Article by Zhou Zhongyi [0719 0022 3015], assistant researcher, Geochemical Research Institute, Chinese Academy of Sciences: "Substantial Prospects for Oil and GAS in the Overly Low Temperature Gradient Deep Parts of the Tarim Basin"]

[Text] The modern ground temperature gradient in the Tarim Basin is too low, generally about  $2^{\circ}\text{C}/100\text{ m}$ . The primary oil-generating strata in the region are the Paleozoic and Mesozoic groups. We have studied ancient ground temperatures in some regions of Xinjiang in recent years and we have proposed a geological model of ancient ground temperatures. Based on this model, we can explore the process of oil generation and determine the oil generating periods and the depth of oil-generating strata that are in their peak oil-generating periods. Our research shows that middle Carboniferous system oil-generating strata now buried at a depth of 5,300 meters in the Bachu region are in the period of peak oil generation. The middle Carboniferous system on the Markit slope is buried at a depth of about 8,000 meters and its oil generation period began 2.4 million years ago. Because it has been buried at rather shallow depths (about 1,200 meters) continually up to the Miocene, it had not yet been able to enter the period of peak oil generation up to the Mesozoic and is now at the condensate stage.

The He-2 well encountered a xylovitrain reflection rate of 0.77 percent in the middle Carboniferous system at 3,060 meters. It can be inferred from this that the middle Carboniferous system in the ventral part of the Tarim Basin must be buried at depths of 5,000 to 6,000 meters before it can enter peak oil generation. Similar conclusions were drawn during research on the degree of maturity of oil generating strata at the Yuecan-2 well.

The deepest oil pools known at the present time are located in the Gulf of Mexico Basin in the United States and lie at depths of 6,540 meters. The deepest gas pools are located in the Anadarko depression in the western United States. The producing strata are lower Ordovician carbonatite that is 7,663 to 8,083 meters deep.

An understanding of the preservation conditions of deep oil and gas pools is of extremely important and real significance for oil and gas exploration in the Tarim Basin.

The results of experiments on a high-temperature, high-pressure model for crude oil that we carried out in 1972 showed that pressure is favorable for preservation of hydrocarbons up to rather high temperatures. The results of experiments we have done in recent years concerning the pyrometamorphosis of Yaomo Shan oil shale also show that pressure can slow the progress of hydrocarbon destruction caused by heat. It can be concluded from this that during the high temperature stage (after the period of peak oil generation), temperature increases will accelerate the process of oil pool destruction and methanization and that pressure increases can slow this effect.

During work several years ago, we discovered that another type of organic matter may have generated oil in carbonatite strata within the Tarim Basin. Middle and upper Carboniferous limestone collected in the Kuluziman area had two times as much soluble organic matter as normal samples of bitumen A. A similar situation was found in Tertiary dolomite near Yuliquan.

Unit cell soluble organic matter has the characteristics of fairly low paraffin content and rather high asphalt content. These characteristics are most obvious in the unit cell organic matter in low maturity carbonate rock.

The results of experiments on high-temperature, high-pressure pyrometamorphosis show that unit cell organic matter is converted into oil and gas only when the organic matter can be preserved to a relatively high stage of maturity. A substantial amount of unit cell organic matter exists within the Paleozoic carbonatite strata in the Tarim Basin and it should have provided another type of oil and gas material for deep strata.

Casein base buried at great depths can produce natural gas after pyrometamorphosis. We did artificial gas generation modelling in six casein base samples (five type III in one group and one type I in the other). Pure casein base was sealed inside a hard glass tube filled with helium and the groups were heated to 450°C and 600°C respectively for 100 hours. The results of the experiment showed that the respective conditions described above correspond to the end of oil generating and the dry gas stage. The amount and constituents of the gas produced were measured after pyrolysis. The results of the experiment were that the type III casein base had a gas production rate of 200 cubic meters/ton and that the type II [as published] casein base had a gas production rate of 250 cubic meters/ton. In combination with the total thickness and organic matter content of the oil generating rock in the various oil generating systems in the Tarim Basin that was synthesized by Kang Yuzhu [1660 3768 2691], calculations can be made of the amount of oil produced by Paleozoic and Mesozoic oil generating strata systems buried at rather great depths in the Tarim Basin. The Tarim Basin covers an area of 560,000 square kilometers. If we assume the oil generating rock to be distributed over 200,000 square kilometers, then the basin could produce  $1.2 \times 10^{15}$  cubic meters of natural gas. If we temporarily assume that the natural gas has an accumulation coefficient of 1 percent, then the basin could have accumulated  $1.2 \times 10^{13}$  cubic meters of gas. If we use a rate of 1,000 cubic meters of

natural gas as being equivalent to 1 ton of crude oil, then the amount of gas in deep strata throughout the basin would be equivalent to 12 billion tons of crude oil, which is a very considerable amount.

It can be seen from this that oil pools may have been protected in the deep parts of the basin and that there is a possibility of fairly large oil pools. Further clarification is needed concerning the richness and types of organic matter in the oil generating strata of this region. Oil generating strata at the surface have been subjected to intense weathering and there has been a decline in the amount and quality of organic matter. I propose that in the future we strengthen research on the oil generation potential of underground oil generating strata. To improve the economic results of exploration, I propose that attention be given to the possibility that oil and gas produced in deep strata may have migrated to shallow positions to form oil and gas pools. The oil and gas pool at about 3,000 meters at Kekyar was formed by oil and gas that migrated from deep areas. Contemporaneous fractures developed here have linked up the deep oil generating strata but have not intersected the overlapping capping strata, and they have caused oil and gas from deep strata to accumulate in shallow reservoir strata. The costs of exploration for shallow oil and gas pools are fairly low and it is an area of exploration where results could be obtained quickly.

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## OIL AND GAS

### ANALYSES ATTEMPT TO IDENTIFY OIL SOURCE OF SHACAN-2

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6, SPECIAL ISSUE, Jun 85 pp 28-30

[Article by Zeng Xianquan [2582 2009 0356], engineer, Geology Brigade of the Ministry of Geology and Mineral Resources' Northwest Petroleum Geology Bureau: "A Discussion of the Oil Source Question at the Shacan-2 Well"]

[Text] At 4:00 a.m. on the morning of 22 September 1984 an intense blowout occurred at the Shacan-2 well, revealing the bright prospects for petroleum surveys and prospecting in the northeastern depression of the Tarim Basin. Indications of oil and gas were discovered in the 3,876 to 3,892 meter segment of the well (in the Miocene system Jidike group) and interpretations of well measurements indicate a possible oil-bearing stratum. Well measurement data indicates that it is possible that oil and gas also can be found in the Jurassic system. A blowout occurred during the process of lifting the drill at a depth of 5,391.18 meters and the oil-producing well segment should be between 5,335.76 meters (the depth of the 7 inch tail pipe) and 5,391.18 meters. The fact that more than 20 cubic meters continued to leak when the slurry ratio reached 1.23 has been used to calculate that the pressure at the well bottom should be less than 663 atmospheres.

It is possible to learn from K-83-05 line, TB-80-302 line and K-82-92 line seismic data that there is a possibility that there are no Carboniferous or Permian system marine facies sediments near the Shacan-2 well, or that they are very thin, and that Cambrian and Ordovician system sediments are somewhat thicker, that the Jurassic is fairly thin or absent in the sediments of the Awat-Manjiaer depression and that the sediments in the Kuqa depression are of enormous thickness, that the Triassic system is very thick in the Awat-Manjiaer depression and in the Kuqa depression, and that all contain relatively thick dark argillaceous rock that may have generated oil.

Cambrian and Ordovician sediments are rather thick and contain marine facies carbonatite, but we lack geochemical data and still cannot come to a conclusion at the present time concerning whether or not they have the conditions for oil generation.

There is very little possibility of Carboniferous and Permian system oil generation. The Kalasu He profile and the Yeyungou profile at the northern

margin of the Kuqa depression show very thick marine facies or sea-land interchange facies Carboniferous and Permian system carbonate rock and agrillaceous rock, but both have been metamorphized to different degrees. The trichloromethane and bitumen contents in 18 samples from the Carboniferous and Permian system in the Kalasu He profile all were less than 30 ppm. Although some of the samples had high concentrations of organic carbon, it is not possible that they served as oil generating rock. While petroleum may have been produced prior to metamorphism, the crude oil near the Shacan-2 well confirms that they are unrelated.

The Triassic and Jurassic systems containing rather thick strata of dark argillaceous rock at the Yuecan-1 well, Shacan-2 well and Acan-1 well in the Awat-Manjiaer depression, in the Kuqa He profile in the Kuqa depression, in the Kapushalang He profile and in the Baozidong profile (see Table 1). The Jurassic system in the Kuqa He profile has an average organic carbon content of 2.36 percent and an average trichloromethane and bitumen content of 0.0614 percent. The Triassic system has an average organic carbon content of 1.11 percent and an average trichloromethane and bitumen content of 0.0324 percent. The Triassic system at the Yuecan-1 well has an average organic organic carbon content of 1.24 percent, an average trichloromethane and bitumen content of 0.0999 percent and an average hydrocarbon content by 175.5 ppm. The lenticular body reflection rate  $R_o$  at the Yuecan-1 well was 0.67 percent between 4,111.27 and 4,111.90 meters, 0.68 percent between 4,429 and 4,430 meters and 0.60 percent between 4,722.11 and 4,724.26 meters. The lenticular body reflection rate  $R_o$  measured using coal in the Kuqa He profile was 0.75 percent for the Kizil Nur group and 0.65 percent of the Taliqike. It can be seen that the Triassic system in the Awat-Manjiaer depression and the Jurassic and Tirassic systems in the Kuqa depression all have entered the stage of maturity. Data from a scanning electron microscope shows that the casein base in the Triassic system at the Yuecan-1 well and the Jurassic and Triassic systems on the Kuqa He profile is of a saprolitic-sapropelic type. Atomic comparisons and the pyrolytic chromatography hydrogen index ( $S_2$ /organic carbon) and oxygen index ( $S_3$ /organic carbon) indicate that the casein base from the Triassic system at the Yuecan-1 well is of type III.

Table 1. Thickness of Triassic and Jurassic System Dark-Colored Mudstone

| <u>Location</u>        | <u>Thickness of dark-colored mudstone (meters)</u> |                 |
|------------------------|--|-----------------|
|                        | <u>Jurassic</u>                                    | <u>Triassic</u> |
| Yuecan-1 well          |  | 326.25          |
| Shacan-1 well          |  | 218.5           |
| Acan-1 well            |  | 188.0           |
| Kuqa He profile        | 676.98   | 914.53          |
| Kapushalang He profile | 457.34   | 519.10          |
| Baozidong profile      | 322.05   | 609.82          |

Crude oil analysis data (Tables 2 and 3) shows that the degree of evolution of the crude oil from the Yuecan-2 well is rather low (the fore-running point was 153°C and the total cut fraction at 304°C was only 41.2 percent; moreover, the Xinjiang Petroleum Management Bureau discovered porphyrin in the crude oil, which is a characteristic of continental facies crude oil (the  $\delta^{13}\text{C}$  value was -3.241). The results of saturated hydrocarbon chromatography were quite similar for the Shacan-2 well and for crude oil from Tugeerming, Yiqikelike and eastern Qiulitake. The crude oil from these three regions already has been confirmed as crude oil produced during the Triassic and Jurassic systems. Comrades Zhan Jiazen [6124 1367 4394] and Lu Jijun [7120 4949 6511] with the Xinjiang Petroleum Management Bureau have examined sporo-pollen in the crude oil from the Shacan-2 well and determined that it is from the middle to late Triassic.

Table 2. Comparison of Crude Oil Saturated Hydrocarbon Spectra and Carbon Isotopes

| Item/Site where sample was collected | Sample number                   |                                       |  |                                  |                                  |
|--------------------------------------|---------------------------------|---------------------------------------|--|----------------------------------|----------------------------------|
|                                      | You-2<br>Shacan-2<br>well       | Yu-yi 464-1<br>Yiqikelike<br>oil pool | Yu-dongqui 1-3<br>East Qiulitage<br>Dongqiu-1 well | Kangcun-4<br>Kangcun<br>oil seep | Yu-Mi-<br>2 well-2<br>Misibulake |
| Carbon number range                  | C <sub>9</sub> -C <sub>32</sub> | C <sub>13</sub> -C <sub>27</sub>      | C <sub>13</sub> -C <sub>30</sub>                   | C <sub>13</sub> -C <sub>30</sub> |                                  |
| Main peak location                   | C <sub>17</sub>                 | C <sub>17</sub>                       | C <sub>17</sub>                                    | C <sub>16</sub>                  |                                  |
| OEP                                  | 1.01                            | 1.07                                  | 1.07   | 0.98                             |                                  |
| Pristane/phytane                     | 1.22                            | 2.21                                  | 1.81   | 1.78                             |                                  |
| Pristane/n-C <sub>17</sub>           | 0.49                            | 0.37                                  | 0.26   | 0.16                             |                                  |
| Phytane/n-C <sub>18</sub>            | 0.44                            | 0.19                                  | 0.18   | 0.09                             |                                  |
| $\delta^{13}\text{C}$ (percent)      | -3.241                          | -2.7471                               | -2.5576  | -2.6979                          | -3.1055                          |

Table 3. Comparison of the Physical Qualities of Crude Oil

| Item   | Shacan-2 well | Tugeerming<br>301 well | Yiqikelike<br>164 well | East Qiulitage<br>Dongqiu-1 well |
|--|---------------|------------------------|------------------------|----------------------------------|
| Specific gravity (D <sub>4</sub> <sup>20</sup> ) | 0.8480        | 0.8178                 | 0.7816                 | 0.7821                           |
| Kinematic viscosity (20°C)                       | 9.17          | 3.33                   | 1.93                   | 1.22                             |
| Point of solidification (°C)                     | -13.0         | 2.0                    | less than -13.0        | less than -13.0                  |

|                               |                    |                   |      |      |
|-------------------------------|--------------------|-------------------|------|------|
| Sulfur content<br>(percent)   | 0.43               | 0.29              | 0.10 | 0.18 |
| Paraffin content<br>(percent) | 2.73               | 2.41              | 2.71 | 0.02 |
| Fore-running point<br>(°C)    | 153.1              | 82.4              | 48.8 | 51.6 |
| Total fraction<br>(percent)   | 41.50<br>(304.2°C) | 72.5<br>(309.5°C) | 77.8 | 94.5 |

The strata that produced the crude oil at the Shacan-2 well generally is felt to be the weathered zone at the top of the Cambrian and Ordovician systems. If the Cambrian and Ordovician systems generated and reservoired their own crude oil, then there are two possible periods during which the oil may have been formed. The first was after the accumulation of Mesozoic and Cenozoic strata (secondary oil generation) and the second was during the later part of the Cambrian and Ordovician systems (the petroleum first accumulated in favorable structures, underwent Mesozoic and Cenozoic structural activity, and then re-migrated to accumulate in the weathered zone at the top of the Cambrian and Ordovician systems). If the latter situation was the actual case, then the crude oil should have a high degree of evolution. The crude oil now being discovered, however, has a low degree of evolution so the possibility of the latter situation is very small.

I feel that there is a very great possibility that the crude oil in the Shacan-2 well came from Triassic and Jurassic source rock. The Yakela structural oil pool is a buried hill oil and gas pool with "oil that is generated in new rock and reservoired in old rock." The fact that the crude oil came from the weathered zone at the top of the Cambrian and Ordovician systems, however, means that some indicators of marine facies sediments such as rather high vanadium-nickel ratios may have been obtained during the process of migration and preservation.

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## OIL AND GAS

### OIL SOURCE ANALYSIS IN SHACAN-2 GENERATES GREAT OPTIMISM

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6, SPECIAL ISSUE, Jun 85 pp 31-33

[Article by Yang Bin [2799 2430], chief geologist, Oil Generation Laboratory, and Wang Baoyu [3769 1405 6877], deputy chief geologist, Fluids Laboratory, Exploration and Development Research Institute, Xinjiang Petroleum Management Bureau: "Using Analysis of Crude Oil From Shacan-2 Well To Forecast Prospects for Oil in Tarim Basin"]

[Text] The high output oil and gas flows from the Shacan-2 well have excited everyone. During the national holidays [October 1984], workers in our laboratories already were involved in urgent analysis and chemical experiments.

#### I. The Crude Oil at the Shacan-2 Well Was Formed in Continental Facies During the Upper Triassic and Middle Jurassic

Based on the position of the Shacan-2 well in geological structures, the possible distribution of oil generating strata, the geochemical properties of the crude oil and comparative data on oil sources, we feel that the oil and gas flows from this well have obvious continental facies characteristics and that they have genetic relationships with the continental facies middle and upper Triassic system and middle Jurassic system oil generating strata that are so widely distributed through the eastern Tarim depression and the Kuqa depression.

1. The specific gravity of the crude oil from the Shacan-2 well is 0.848, the paraffin content is 5.03 percent and the sulfur content is 0.30 percent. The two key fractions of the crude oil (the 250° to 275° C fraction and the 395° to 425° C fraction) that specific gravities of 0.8272 and 0.8863, respectively, API specific gravities of 38.7 and 27.4, respectively, and the characterization factor K of both was 12. The classification according to the characterization factor of the crude oil should be intermediate base crude oil with a partial paraffin base. Analysis of family and group gives a saturated hydrocarbon to aromatic hydrocarbon ratio of 4.96 for the crude oil from the Shacan-2 well. The same figure for the mixed crude oil at Yiqikelike is 4.50, but is 12.66 for Kekyar crude oil. We can see that the crude oil from the Shacan-2 well is similar to that from the Yiqikelike oil pool and that apparently there is a causal relationship between the crude oil at Yiqikelike and the middle Jurassic Kizil Nur group in the Kuqa depression.

2. The normal paraffin distribution curve of the crude oil is approximately the same as that for samples taken from the dark colored mudstone of the Kizil Nur group at the Liushen-1 well in the Kuqa depression but is quite different from samples of marine facies upper Carboniferous gray limestone taken from wells in the Bachu region.

3. We discovered (aoli) hydrocarbon in the crude oil at the Shacan-2 well. This organism indicates that the compound comes from terrigenous plants and was discovered first in oil generating rock in the Nigerian Delta. It also has been discovered in crude oil from the Shahejie group in the central Hebei depression and the Jurassic system in the Ordos Basin.

4. We used triangulation charts and right angle coordinate charts to illustrate the distributional characteristics of C<sub>27</sub>, C<sub>28</sub> and C<sub>29</sub>, which are three types of conventional steroid alkyls, and we discovered that the crude oil from the Shacan-2 well bears a rather close relationship with the Kizil Nur group oil generating rock at the Liucan-1 well and that it is unrelated to the upper Carboniferous gray colored limestone from the Bachu well.

5. The crude oil from the Shacan-2 well has a  $\delta^{13}\text{C}$  value of -3.250 percent, a saturated hydrocarbon content of hydrocarbon -3.265 percent, an aromatic hydrocarbon content of -3.204 percent, a non-hydrocarbon content of -3.177 percent and a bitumen content of -3.272 percent. According to Erdman's "Distributional Chart of the Components of Carbon Isotopes of Various Types of Organisms in the Natural World" (1975), the crude oil from the Shacan-2 well should be included within the scope of non-marine facies crude oil. W. J. Stahl's chart of  $\delta^{13}\text{C}$  distributions during different geological periods indicates that it should be considered a product of Triassic oil generating strata. Through comparison with data on samples from the Kizil Nur group from the Kuqa depression (the Liushen-1 and Liushen-4 wells), the Triassic system in the Awat depression (the Acan-1 well) and the upper Carboniferous system oil generating rock, we also discovered that the crude oil from the Shacan-2 well most closely resembles the Triassic system and that the next best is the Jurassic system, and furthermore, that it has a rather poor relationship with the marine facies Carboniferous system.

Comrade Zhan Jiazen [5124 1367 4394] of our academy found 70 sporo-pollen fossils in samples of crude oil from the Shacan-2 well and determined that they were from the middle and late Triassic. This sporo-pollen assemblage had the following characteristics:

- 1) Pteridophyta spores occupy a predominant position in the assemblage with a content of 70 percent, while gymnosperm pollen accounted for 30 percent.
- 2) Calamospora, Punctatisporites and Todisporites accounted for the highest pteridophyta spore content. The assemblages also included a certain amount of Aratrisporites, which are a typical Triassic era group. This group was the most common in the sporo-pollen assemblages from the middle Triassic and the early part of the late Triassic in the Soviet Union, and they appear mainly in middle and late Triassic strata in the Ordos Basin and at the southern margin of the Junggar Basin in China and may have extended into the early Jurassic in some places.

3) The gymnosperm pollen is mainly blastoid conifers, while ribbed diploblastula pollen (like Protohaploxylinus) and the monoblastula pollen Cardaitina account for a sizeable proportion of the assemblage. Chordasporites and monocolpus pollen appear in some areas.

This assemblage is similar to the sporo-pollen assemblage from the Triassic system Karamay group at the Yuecan-1, Shacan-1 and Acan-1 wells in the northern part of the Tarim Basin, and it may be compared with the Ermaying group in the Ordos Basin and the Karamay group at the southern edge of Junggar Basin.

In light of the above information, our preliminary idea is that the crude oil from the Shacan-2 well may have been created in continental facies and that it is related primarily to the formation factors of the middle and upper Triassic system and the Kizil Nur group of the middle Jurassic system that is distributed widely to the north and south of the Xayar uplift. Nevertheless, we first of all felt that the crude oil from this well came from marine facies. The reason was that the test results we obtained during the middle part of October 1984 indicated that the vanadium porphyrin content of the crude oil was 11.15 ppm and the nickel porphyrin content was 0.96 ppm, a ratio of 11.61 between the two. Atomic absorption spectral analysis of the crude oil ash content indicated a vanadium content of 2.28 ppm and a nickel content of 0.46 ppm, a V/Ni ratio of 4.98. Emission spectral analysis of the crude oil ash content indicates a vanadium content of 16.7 ppm and a nickel content of 1.99 ppm, giving a V/Ni ratio of 8.79. Further analysis of various types of data has compelled us to reconsider the reliability of the proposition that "all crude oil with a high vanadium/nickel ratio is marine facies crude oil." Just as A. S. MacKenzie has said, "It often is quite difficult to use a modern understanding of the formation conditions of petroleum to explain differences in porphyrin distributions."

It should be pointed out that no outcrops of Carboniferous and Permian system marine facies or older marine facies strata have been discovered in the basin to the east of Hotan He and no data of any sort of this area has been obtained from any well. Since the lenticular body reflection rate of coal strata in the 5,323 to 5,324 meter section of the Shacan-2 well had reached 1.36 percent, then the Carboniferous and Permian systems that are buried at 6,000 to 7,000 meters on the southern and northern sides already should have passed through the state of maturity. How then, can there be porphyrin? How is it possible that there is crude oil that has not reached a fairly high state of maturity? The proposition that the Cambrian and Ordovician systems are the source rock is a bold inference. The reason is that the lenticular body reflection rate of this set of lower Paleozoic strata already has reached 3 to 5 percent at the surface of the Bachu uplift and there still is some question as to whether it exists to the east of the Hotan He.

## II. Beautiful Prospects for Petroleum Exploration in the Basin

Some 196 structures already have been discovered in the Tarim Basin and industrial oil flows and oil and gas seeps have been found in 32 structures or regions. Marine facies Carboniferous-Permian, marine facies upper Creaceous-lower

Tertiary and continental facies Triassic-Jurassic oil generating rock systems are distributed widely throughout the 560,000 square kilometer basin.

### 1. Continental facies Triassic-Jurassic oil generating strata systems

The Tarim Basin was in an inland rift valley stage during the Triassic-Jurassic and formed fault-subsidence garben lake and swamp facies sediments, each of them unconnected and developing independently. The Kuqa, eastern Tarim and southwestern depressions cover a total area of 200,000 square kilometers and have oil generating rock 250 to 450 meters thick. The Yiqikelike oil pool, Yangye oil seep and Kekyar oilfield that now have been discovered all are found within the scope of this set of oil generating rock systems and it is quite possible that it was the source rock for these oil pools and seeps. In addition to those related to the differences in biogenesis in the different regions, the differences in the qualities of the crude oil from them may be due to differences in the degree of maturity. The crude oil from the Shacan-2 well is related to the conditions of its formation. The Kuqa depression to the north of the Xayar uplift covers an area of 18,500 square kilometers and the eastern Tarim depression to the south covers an area of 50,000 square kilometers. Gas and oil may be obtained from the large oil generating depressions to the north and south of the Xayar uplift. This is the reason for the abundance of oil and gas at the Shacan-2 well, and it also is the material foundation for the hope that large oil and gas accumulation zones may have formed.

### 2. Carboniferous and Permian system oil generating strata systems

These occur mainly at Kalpin, Bachu and the southwestern depression. The Tarim Basin had undergone a complete process of marine intrusion-marine regression at that time. In the early Carboniferous, it began as an above-tide zone and lagoonal facies, and accumulated thin strata of dolomite interbedded with powdery sandstone and black-colored battie. Later, the seawater gradually became deeper and developed above-tide zone sediments such as nuclear rock sparry limestone, algae group oolitic limestone and so on. The marine intrusion expanded gradually during the middle Carboniferous and the sea water again became deeper. In addition, the continuous supply of terrigenous detritus from Kunlun Shan formed a set of below-tide low energy zone--intertidal zone and fluvial-sea deltaic accumulations in the southwestern depression that included various types of biomicritic limestone, black-gray shale, quartz sandstone and so on. During the late Carboniferous, intertidal beach facies predominated, with local occurrences of below-tide low energy zone micritic limestone and above-tide zone micritic dolomite accumulations. During the early Permian period, the area to the west of the Xinjiang-Xizang highway was primarily semi-occluded marine regression littoral facies sediments, while the eastern part was continental facies gray-black mudstone accumulations.

This group of oil generating rock includes various types of biomicritic limestone and black and gray shale with a total thickness of 500 to 1,000 meters. It is distributed over an area of about 191,000 square kilometers to the east of Hotan He.

We found bitumen veins, bitumen blocks and miarolitic light quality oil seeps at rather high degrees of maturity on the Heshilapu, Kizilqiman and other profiles from Kalpin and Bachu to the southwestern depression. This group of oil generating strata has a lenticular body reflection rate of 1.30 to 1.83 percent and is a set of highly mature to overly mature oil generating rock. If we wish to locate oil and gas pools related to marine facies Carboniferous and Permian system oil generating strata, we should, therefore, look in the area of Kalpin, Bachu and the southern depression, and it is quite possible that it mainly is highly mature light quality oil and natural gas.

### 3. Marine facies upper Cretaceous-lower Tertiary oil generating strata systems

During the late Cretaceous, the seawater again intruded from the west into the Kashi-Yecheng region, flooded all of the narrow region to the south of a zone from Akto to Shache, and accumulated sediments from 400 to 700 meters thick. During the early Tertiary, the marine intrusion expanded to the edge of the Bachu uplift and eastward to Aqike and formed continental margin sea to semi-occluded shallow sea facies accumulations. Oil generating rock in the Kukebai group, Qimugen group and Wulagen group has dark mudstone 200 to 300 meters thick and carbonatite 50 to 100 meters thick. The oil generating rock covers an area of about 26,000 square kilometers. In this group of oil-generating strata, oil sands, bitumen, paraffin, liquid oil seepages and other indications of oil and gas that were generated and reservoired in the same rock were found at Yuliquan, Keliyang, Sangzhu and other sites.

Based on the geological characteristics of these three groups of oil generating strata and rough calculations made through data from geochemical analysis, the Tarim Basin has oil and gas resources of about 6 to 8 billion tons.

In summary, the Tarim Basin has abundant petroleum resources and may contain many petroliferous structures. The prospects for exploration are excellent. We must note, however, that the Tertiary strata and above throughout most of the basin are quite thick. The target strata are deep and the geological conditions are complex. Possible petroliferous structures are complex and the degree of exploration is low. We must have more satisfactory exploration achievements and we must centralize petroleum geology forces within China to learn from the strong points of others to make up for deficiencies, to work together with one heart, make large and arduous efforts and intensively and meticulously work to do good geological exploration and research work and be conscientious in solving each basic problem of petroleum geology according to scientific exploration procedures and methods.

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## OIL AND GAS

### IMMEDIATE TARGETS FOR EXPLORATION IN TARIM BASIN SUGGESTED

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6, SPECIAL ISSUE, Jun 85 pp 38-39

[Article by Gao Zhenjia [7559 2182 1367], advanced engineer, Geological Research Institute of the Xinjiang Geology and Mineral Resources Bureau: "Some Views on Oil Exploration in the Tarim Basin"]

[Text] The news of high output oil and gas flows at the Shacan-2 well was extremely exciting. This not only brought hope for an economic take-off in southern Xinjiang but also showed that there are beautiful prospects for petroleum exploration work in the Tarim Basin. Based on the news that followed the flow of oil from the Shacan-2 well and in combination with the results of his regional geological survey of the northern margin of the Tarim Basin, the author offers the following points of understanding concerning oil petroleum exploration in this region.

#### I. Geological Characteristics of the Oil-Bearing Region

It has been confirmed that the geological structure of the Tarim Basin is a stable platform and that its development has an obvious polycyclic nature. The platform has a pre-Cambrian Yangzi basement. Structural development within the platform since the Paleozoic has had a long-term and continuous quality. This is one of factors that deserves attention to oil exploration work. The sedimentary capping strata on the platform include enormously thick marine facies and continental facies multiple oil generating strata systems from the Sinian, lower Paleozoic, upper Paleozoic, Mesozoic and Cenozoic eras and they show the polycyclic nature of the oil generating sediments. Furthermore, the fact that the platform was subjected to Tarim orogeny, the late period of Variscan orogeny and other influences means that the region has superior oil generation and reservoiring conditions. The characteristics of the oil pool at the Shacan-2 well also reflect the polycyclic formation and development of the petroleum in the region.

#### II. Eras of Reservoir Strata at Shacan-2 Well

The Northwest Petroleum Geology Bureau sent two samples of detritus from the producing strata. They are primarily white fine crystalline dolomite with a small amount of dolomitic crystalline limestone and siliceous fragments, and

some of the dolomite has weathered characteristics. Comrade Peng Changwen [1756 2490 2429] of the Geological Research Institute did micropaleobotanical, conodont and other analysis and processing of the samples but obtained no results. The author examined them under a stereoscopic microscope and discovered a laminar fragment that may be the laminae of stromatolithic rock, but this cannot be confirmed at present because the fragment was too small. It is inferred that the oil-bearing rock is crystalline dolomite or dolomitic limestone that contains siliceous concretions or belts. This type of lithology is found in the Cambrian system (Awatage group), Ordovician system (Qiulitage group), Sinian system (Qikebulake group), the Jixian system (Aierjigan group) and the Qingbaikou system (Paergangtage group). The author suggested the possibility that petroleum could be found in the early Paleozoic or even older eras in the Tarim Basin, and this now has received preliminary confirmation by data from the Shacan-2 well. The era of the reservoir strata, however, cannot be determined at the present time. Although it is felt on the basis of lithology in combination with seismic information that the greatest possibility is that it is the Ordovician Qiulitage group, the fact that the rock contains a large amount of magnesium, the rather good crystallization and analysis of questionable laminar rock fragments means that the possibility cannot be eliminated that it is from even older strata (the Sinian system to the Jixian-Qingbaikou systems). Laminar rock is even more common in the pre-Cambrian system in nearby areas (it also has been discovered in the Cambrian and Ordovician systems at Kalpin). I propose that a systematic examination be made of the rock cores (fragments) obtained and that slicing or other methods be used for microscopic analysis of the siliceous fragments they contain.

Furthermore, petrochemical and other methods should be used to compare them with the trace elements in Paleozoic and pre-Cambrian carbonatite from nearby surface outcrops to clarify further their age.

### III. Concerning Oil Generating Strata

The author feels that there is not one oil (and gas) source of the oil and gas from the Shacan-2 well, and that it is possible that there are two or more oil sources. The preliminary inference is that the oil generating strata are from the Carboniferous to lower Permian systems. This can be illustrated by the biochemical indices of the crude oil, by data from nearby parameter wells and by geological and geophysical achievements. Moreover, the lower Paleozoic (or the pre-Cambrian) system also is one of the oil sources. The degree of richness of organic matter content in the lower Paleozoic is less than in the upper Paleozoic, however, so it is possible that it is only a secondary oil source stratum. This is especially true in terms of the Shacan-2 well. If it is determined that the oil is reservoired in a weathered crust, then the early Paleozoic carbonate rock that composes the weathered crust would cause it to contain oil and would have been fostered early by the weathering. Most of the oil and gas in existing oil pools migrated in from other places. All the oil-bearing strata from the two periods above are marine facies oil strata, which conforms to current conclusions from analysis of oil, gas and water. A consideration of the geochemical characteristics and structural conditions indicates that there is little possibility that the Triassic system is the primary oil source for the Shacan-2 well, and that it is an even

more secondary oil source. It would have been quite difficult for oil and gas from the oil generating strata in the Jurassic and Cenozoic systems to have migrated and accumulated in the direction of the Shacan-2 well.

#### IV. The Direction for Further Oil Exploration in the Northern Tarim Basin

1. There is no doubt that the focus should be the Xayar uplift and we should follow victory with hot pursuit. Strengthen exploration of high gravity zones along the uplift zone that have received preliminary determination and search for similar oil reservoiring structures, oil generated and reservoired in the upper Paleozoic and other types of oil pool traps. Deployments should be speeded up in the high gravity zones running eastward, northeastward and in other directions at the Shacan-2 well, in the high gravity zone at Luntai and in other very favorable prospective regions. There are quite a few oil and gas indications in the Yengisar and Qarqi areas to the east of Luntai County. The Third Brigade of the Xinjiang Geology and Mineral Resources Bureau drilled into shallow strata of oil sands in the coal system strata of the Jurassic system during the 1970's. Therefore, besides concern for Paleozoic oil pools, we should also give attention to oil pools that were generated and reservoired in the Mesozoic. The geological conditions of the Yuli platform uplift region to the southeast of the Xayar uplift zone are similar to those at the Xayar uplift and geophysical exploration and exploratory drilling work should be done on the outer perimeter.

2. It was determined quite early that oil pools were generated and reservoired in the Jurassic system in the Kuqa depression, but nothing is known of the distribution and oil-bearing qualities of the late Paleozoic system strata lying below. Relatively advanced geophysical exploration methods should be adopted to investigate deep structures and to resolve problems related to drilling in high pressure aquifers and explore deep strata. This is the second step of work.

3. Upper Carboniferous-lower Permian system biogenetic reef limestone developed in the transitional zone regions to the north of Kalpin and at the northern margin of the Tarim platform and there are indications of oil and gas at the base of the reefs and nearby. Continual investigations of high output biogenetic reef oil pools now being done in foreign countries also have led to the discovery of biogenetic reef oil and gas pools in China, so attention should be given to the biogenetic reefs and their oil-bearing qualities in this region. We first of all should develop surface studies and further determine the regions where reef limestone is found buried under the Tertiary or Mesozoic systems in areas such as the Qilikeshayi Basin and the gentle Tertiary structural zone running north from Aksu to Baicheng, where it is quite possible that the upper Paleozoic and Mesozoic can be found in the lower parts. I propose that geophysical exploration and topical research be developed.

4. High precision aeromagnetic measurements and fairly large scale surface gravity, magnetic and seismic work should be done in favorable sections of the above regions to determine basement rises, the distribution and attitude of uplifts, depressions and fractures (including concealed Paleozoic fractures) and to discover more favorable oil reservoiring structures.

## OIL AND GAS

### BASIN THEORY TO PROMOTE NEW DISCOVERIES IN TARIM

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6, SPECIAL ISSUE, Jun 85 pp 40-41

[Article by Gan Kewen [3927 0344 2429], senior engineer, Petroleum Exploration and Development Research Institute, Ministry of Petroleum Industry: "Basin Theory Will Promote New Discoveries at 'Tarim'"]

[Text] Seven years passed between the discovery of the high-output oil and gas field at Kekyar in the southwestern part of the Tarim Basin in 1977 and the discovery of high output oil and gas flows in the Yakela structure in the northern part. This indicates that the Tarim Basin truly does have excellent oil and gas prospects, but also illustrates the complexity of the basin as well.

Past oil and gas prospecting in China has been concentrated mainly in relatively singular sedimentary basins. This makes it understandable that there could be some temporary difficulties involved in exploration of a complex basin like Tarim with its multiple combinations and overlapping pattern of several types of basic basins.

Actually, the transformation of Tarim into a unified basin component only occurred in recent times following the later Tertiary. Major differences exist between different locations in the basin, each of them expressed as individual sedimentation and structural characteristics that thereby determine the different petroliferous prospects.

It is possible that Tarim was a sea platform surrounded by a deep sea trench during the Paleozoic, which is indicated in seismic data. Within the scope of the central platform region, the reflection strata are extremely stable, regardless of whether it is an uplift region, a subsidence region or a sloping region, and there are no obvious changes in temporal separation. Intense reversal, folding and thrust faulting occurred in the sea trench region during the Hercynian movement and resulted in denudation of the strata. The sea platform region was uplifted in a level fashion and was associated with fracturing and leakage of molten basic rock flows. It is possible that the Mesozoic and Cenozoic systems directly overlap the Paleozoic or even the pre-Cambrian systems at the northern Tarim uplift and that the area to its east in the northern part of the Tarim Basin and at the Qiemo uplift and the area to its south in the southern part is a reflection of this type of

change<sup>1</sup>. From then on, Tarim became part of the post-accretionary Eurasian continent.

A major transformation of the Tarim region occurred during the Mesozoic. A continental facies extensional fault-subsidence basin appeared on and near the background of Hercynian folding, thrust faults and uplifts. The central part of the platform was mainly a stable uplift region. The sediments were affected by structural and terrain conditions. The Hercynian folded mountain range near the outer perimeter was mainly coarse detritus and has intense facies transitions. The uplifts near the platform were rather stable and the deep and low subsidence zones were mainly argillaceous rock.

There were even broader sediments during the Cretaceous and early Tertiary eras that were able to overlap directly upon the Paleozoic or even the pre-Cambrian systems. The late Cretaceous and early Tertiary marine intrusion entered the western part of the basin region from central Asia. It is envisioned that the sea water may have extended eastward along some deep fault subsidences at the margin and that the development of evaporite during the lower Tertiary is due to the semi-occluded depressional or lagoonal sediments related to the marine intrusion.

The late Tertiary also was a period of enormous changes. Collision of the Indian plate with the post-accretionary Eurasian plate during the Mesozoic caused a compressional stress field to reappear at Tarim. The Tian Shan range and the Kunlun Shan range resumed intense thrust fracturing and up-lifting, and deep depressions formed by isostatic compensation that extended into the center of the basin formed at the margin of the basin region and accumulated enormously thick (as much as 5,000 to 7,000 meters) red-colored molasse with associated thrust faults and comb-shaped folds.

The development of a plastic strata segment in the Mesozoic and Cenozoic strata sequence gave these compressive structures an interlayer sliding quality that formed surface folds or even piercing structures.

This permits us to divide the evolution of the Tarim Basin into three main periods of time. The early period, the Paleozoic, involved a completely subsided basin. The middle period, the Mesozoic and lower Tertiary, involved a fault subsidence basin within an extensional stabilized region. The late period, the upper Tertiary, was a premontane basin. Based on the basic type of the basin and a global analysis of its oil and gas prospects, the author feels that the early and later periods are not the most ideal prospective strata sequences and that only the internal fault subsidence basin during the middle period is the main target of exploration and has rich potential for oil and gas. According to my understanding of the geodesic structural background of regional oil and gas accumulations, the primary target oil and gas producing strata in all of the basins along the coast of the Caspian Sea that extended from western China through Afghanistan to the Soviet Union and central Asia are the Jurassic to lower Tertiary systems.

According to models of oil and gas accumulations in fault subsidence basins within a stable region, the Paleozoic era below could have formed buried hills

or unconformity denudation fault-block trap oil and gas pools. The overlapping upper Tertiary could have promoted the maturity and further migration and accumulation of oil from Mesozoic and lower Tertiary oil generating strata, even to the point that it may have formed draped structural entrapment oil and gas pools. The regions with the greatest prospects, however, should be those around the deep depression areas during the fault subsidence basin period. Special attention should be paid to sloping zones in the intermediate platform uplift regions and high fault block zones in them and to conceal structures under capping thrust fault slippage structure zones.

Past practice in exploration has proven that making structures formed during the late Tertiary and the oil and gas seepages associated with these structures the basis for exploratory drilling has not provided ideal results. Exploratory drilling in Paleozoic uplift zones often fails because of the lack of porous reservoir strata.

Because of the dark colored argillaceous rock that developed during the Carboniferous and Permian systems and the relatively common oil and gas indications, the possibility of secondary oil generation in the Paleozoic cannot be eliminated. However, strata velocities from seismic reflection profiles for all of the clastic rock dominating the strata sequence entering the Paleozoic that may be of Carboniferous and Permian system origin is 5,500 to 6,000 meters thick, as is the carbonate rock and bedrock, which shows that it has lost any porosity. There is no rational explanation at the present time for the mechanisms of hydrocarbon discharge and migration during secondary oil formation under such conditions. For this reason, whether or not the Paleozoic is considered ancient oil generating strata, the oil and gas indications in them actually have a closed-off quality and cannot confirm that it is a rather low strata velocity Paleozoic region.

In summary, it goes without saying that the Tarim Basin has very good oil and gas prospects, but the zones of rich oil and gas accumulations are rather restricted. The author firmly believes that further exploration along the route of searching for oil in the interior fault subsidence basins from the Mesozoic to early Tertiary should bring about the day of a high tide of oil and gas pool discoveries in the Tarim Basin as quickly as possible.

I thank the organizers of this writer's conference for issuing this not extremely pleasing opinion because it did not receive their attention when I offered a similar position in early 1979. I would like to use this opportunity to express my hope that oil and gas geology workers will pay attention to the role of basin theory so that future exploration work is even more effective.

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## OIL AND GAS

### DRAWING UP A UNIFIED PLAN TO ACCELERATE EXPLORATION IN TARIM

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese No 6, SPECIAL ISSUE, Jun 85 p 42

[Article by Luo Zhetan [5012 5764 3389], professor, Chengdu Academy of Geological Sciences: "Eliminate Obstacles, Unify Deployment, Speed Up Development of Tarim"]

[Text] The Shacan-2 well opened up a high output oil and gas flow and a gusher that erupted without letup for more than a month. This was an especially major achievement in the Ministry of Geology and Mineral Resources' call for development of a second round of oil and gas surveys and in the attack on the "four new's."

According to my understanding of the situation, it may confirm that the Tarim Basin is a petroliferous basin with great developmental prospects and that it will become one of China's important petroleum base areas in the future. I offer the following preliminary viewpoints concerning ways to speed up research and exploration of the Tarim Basin, accelerate the exploitation of the enormous oil and gas potential of the basin and further create a new situation in the search for oil:

1. Strengthened research work on remote sensing geology must play an active role in revealing underground geological conditions and the locations of concealed oil and gas traps.
2. Develop research work concerning reservoir strata geology, especially in the Jurassic, Miocene and Paleozoic weathered crust reservoir strata where oil and gas already have been discovered. We should develop detailed research work. Research on the geology that corresponds to already-discovered reservoir strata and that is related to the development of reservoir strata is an extremely important aspect of oil pool exploration and development. This is especially true of the Paleozoic reservoir strata at the Shacan-2 well. Although there is very little data, we are facing preparations for preliminary development and should use all possible and available related data and indirect data to develop research on this topic at the earliest possible date.
3. The characteristics and theories of oil and gas generation, migration and accumulation indicate that oil and gas pools often have a regularity of

occurring in groups or in belted distributions. This has been proven time and again in oil and gas pool geology worldwide and in the history of exploration and development of oil and gas pools in China. We should, therefore, begin with the breakthroughs at the Yiqikelike oil pool and the Kekyar oil-field to develop comprehensive research and analysis of the geology of oil and gas pools. We should develop comparative analysis of information from all areas, make typical appraisals and carry out meticulous intensive research on surface geology and underground geological facies combinations. There is hope that more and larger oil pools will be found around or below existing oil pools. I feel that the Kekyar oilfield certainly is not an independent one and that it is possible that a second or even a third Kekyar oilfield will be found. It also is possible that Yiqikelike was an easily discovered small oil pool in the upper strata and that much larger and much better oil pools will be found around the outside of or below it.

4. The successes at the Shacan-2 well have revealed completely the richness of the oil and gas resources of the Tarim Basin, especially the rich amounts of oil generated. In the future, greater attention should be paid to research on oil reservoir traps, especially to research on the oil and gas traps formed under appropriate geological conditions in the three sets of oil reservoiring strata that already have been discovered. This in turn requires attention to the search for regions similar in quality to the Xayar uplift to explore for Paleozoic oil pools, and we also cannot neglect exploration for primary and secondary oil and gas reservoirs in Mesozoic and Cenozoic strata.

The degrees of geological research and exploration in the Tarim Basin as a whole are low. To speed up the pace of research and exploration, the most urgent thing is a quick solution for the communications problems that are hindering exploration and development of the Tarim Basin and for the problems related to uniform deployment of the forces in all areas and coordinated battles related to rational exploration and development.

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## OIL AND GAS

### FRACTURE SYSTEM, HYDROCARBON ACCUMULATION IN TARIM BASIN

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6, SPECIAL ISSUE, Jun 85 pp 43-44

[Article by Yan Yugui [7346 3768 6311], assistant researcher, Lanzhou Geological Reserve Institute, Chinese Academy of Sciences: "Fracture Structures and Oil and Gas Accumulation in the Tarim Basin"]

[Text] I. All of the oil-bearing regions in the northwest are closely related to fracture structures and the Tarim Basin is no exception. This is shown primarily in the following areas:

1. Fractures control the distribution of oil and gas. Fractures developed in the axial part of the Yiqikelike oil pool at the northern margin of the Kuqa depression and the fractures controlled oil and gas accumulation. The rich accumulation of oil and gas at the high points of the anticline is greatly related to the role of fractures as migration paths. The oil and gas accumulations in the Kekyar oilfield are closely related to the NW oriented fractures that developed in the lower part of the reservoir strata. The formation of the mineral wax at the northern limb of the Sangzhu anticline, the Cretaceous oil sands to the west of the Yuliquan anticline, the Jilishi oil seeps in the Kuqa depression and the Kangcun oil seep all are related closely to fractures.

2. Fractures control all types of traps. The margins of the southwestern depression mainly developed shear fractures and the drag folds associated with them, and anticlinal traps like the Kekyar oilfield developed in them. Anticlinal traps controlled by fracturing developed in the Kuqa depression. Fault sheltered traps controlled by fractures developed at the northern margin of the norhtern Tarim uplift. Anticlinal traps controlled by fractures developed on both sides of the central uplift.

3. Fractures control the development of oil generating rock systems and reservoir rock systems. The primary source rock in the Tarim Basin are the Carboniferous, Permian, Triassic, Jurassic, and Tertiary Miocene systems. Of them, the development of the Triassic and Jurassic systems is closely related to the fault subsidence basin. The Triassic developed widely in the northern part of the Kuqa depression and at the northern Tarim uplift, and is closely related to the fractures that developed at the northern margin of the Kuqa depression and the northern part of the northern Tarim uplift. Furthermore,

oil generating rock systems and reservoir rock systems are fairly developed. Oil generating rock systems and reservoir rock systems developed within the Jurassic system fault subsidence in the Kuqa depression and the southwestern depression. Tertiary oil-generating rock and reservoir rock developed in the Kuqa depression and in the southwestern depression, and they are closely related to the sequentially falling fault blocks within the basin.

II. Two main factors should be considered when forecasting the oil and gas prospects of a region: The first is whether or not source rock developed and its distributional situation. The second is whether or not traps capable of capturing oil and gas developed. The following preliminary opinions concerning forecasts of the oil and gas prospects of the Tarim Basin on this basis are offered.

1. The southwestern depression is one of the largest prospective oil and gas regions. Source rock is fairly developed throughout this region, with five sets: Carboniferous, Permian, Jurassic, upper Cretaceous-lower Tertiary and Miocene. Among them, the Carboniferous, Permian and Jurassic systems are the primary source strata. The drag folds that developed in association with fractures at the margins of the southwestern depression may serve as traps for oil and gas accumulations. Two groups of joints with NW and NE orientations also developed as local structures in the axial part, and they are fairly conducive to oil and gas migration and accumulation. Examples include the Kekyar anticline and the Yengisar anticline. Furthermore, fractures with a NW orientation developed in the deep parts of the Kekyar anticline that, in combination with the development of pores in reservoir strata, form a filtering system that was conducive to oil and gas accumulation. The area of the southwestern depression with the greatest prospects are the areas near the Kashi depression and the Yechen-Hotan depression. This corresponds roughly to the area south of the Yengisar anticline and to the area to the east between the Kekyar anticline and the Fusha anticline, as well as the Anbu region linking the two depressions mentioned above that formed traps with rather high strata positions that were favorable for oil and gas accumulation. Furthermore, the western ends of the Fusha, Yuliquan and Sangzhu anticlinal zones at the northern margin of the Yechen-Hotan depression can be chosen as suitable regions to explore for Carboniferous and Permian system oil and gas accumulations.

2. The northern Tarim uplift region has greater oil and gas prospects. Triassic and Jurassic source rock developed within this region and there also are deep strata of Carboniferous and Permian source rock or even lower Paleozoic source rock. The Triassic is more widely developed than the Jurassic and is the primary source rock in the northern Tarim uplift. The distribution of the Jurassic is restricted and its oil generation potential is not as good as the Triassic. Source rock is more developed in the Awat-Manjiaer depression to the south of the uplift. The source rock in the Awat depression is mainly from the Carboniferous, Permian, Triassic and Jurassic systems and there is upper Cretaceous and lower Tertiary source rock that also deserves attention. Triassic and Jurassic source rock developed in the Manjiaer depression and the reservoir strata are buried at shallow depths, so it is the most hopeful region for oil and gas exploration at present.

Furthermore, there also is a region to the north of the northern Tarim uplift where fracture zones developed in the parts that were uplifted rather high. Furthermore, it is the highest position to which oil and gas would migrate and accumulate and we should take notice of sheltered traps, fault-block traps and fracture-controlled anticlinal traps.

3. The Kuqa depression is a region with oil and gas prospects. The source rock is mainly from the Triassic and Jurassic systems. The recent exploration situation indicates that the Jurassic is more widely distributed than the Triassic and that the geochemical indices of oil and gas formation are rather good, so it is the primary source rock in the Kuqa depression. Of secondary importance is the Triassic, which is more widely developed in the northern part of the depression, and it also is an important source rock of the depression. There was considerable development of anticlinal traps, fault sheltered traps, salt dome traps and other traps within the depression, so it has certain prospects for oil and gas. Tertiary gaoyan strata have been encountered during exploratory drilling for years, however, and drilling is difficult, so problems remain to be solved. Furthermore, there is a lack of concordance above and below local structures within the depression that require seismic exploration of deep strata to search for anticlinal structures in deep strata.

4. The central uplift has certain oil and gas prospects. This uplift was formed rather early and developed Carboniferous and Permian source rock. Denudation has caused the original sediments to vanish or be preserved only poorly in part of the center of the "uplift," but the Carboniferous and Permian systems have been preserved better on the SW and NE sides of the "uplift" and Tertiary sources rock also developed. Some gentle nose-shaped structures have been found on the uplift. We can explore stratigraphic overlap unconformity traps, strata thinout traps and fault sheltered traps. These areas are the most favorable for oil and gas prospecting on the "uplift."

Moreover, the Jurassic system is rather developed in the eastern Tarim depression and Carboniferous and Jurassic source rock developed in local regions in the southeast fault-fold zone (the Qiemo uplift), so it has certain oil and gas prospects.

The Tarim Basin is the largest prospective oil and gas region in western China, but the levels of exploration and research are low. We should consider doing geological and geophysical exploration work for the basin as a whole and develop comprehensive research work. I hope that related departments of the central government will strive to strengthen exploration for oil and gas resources in the Tarim Basin.

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## OIL AND GAS

### SHACAN-2 AND DIRECTION OF FUTURE EXPLORATION IN TARIM BASIN

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6, SPECIAL ISSUE, Jun 85 pp 45-46

[Article by Kang Yuzhu [1660 3768 2691], deputy chief engineer, Northwest Petroleum Geology Bureau, Ministry of Geology and Mineral Resources: "Discovery of the Shacan-2 Well High-Output Oil and Gas Flow and the Direction of Future Oil Exploration"]

[Text] The discovery of high-output oil and gas flows in the Yakela structure of the Xayar uplift in the Tarim Basin is a major breakthrough of strategic significance in oil and gas surveys and exploration in China, and it is a major geological achievement for an intensive attack on new regions, new spheres, new types and new depths in the second round of oil and gas surveys in China.

The Shacan-2 well is the first high-output oil and gas well on the Paleozoic Tarim platform, and it opened the stage for oil exploration on the Tarim platform. Not only did it open up a new situation in the search for oil in the Paleozoic and especially the lower Paleozoic in western China, but it also provides an example to use in the search for lower Paleozoic oil and gas in eastern China.

According to current results of analysis of the oil and gas, the crude oil at the Shacan-2 well is a product of a marine facies environment. Moreover, analysis of regional petroleum geology conditions suggests that marine facies Carboniferous and Permian oil generating strata are not distributed widely at the Xayar uplift or in nearby areas and that the sediments are rather thin. The Cambrian and Ordovician systems are widely distributed in the region, however, and are of enormous thickness. The preliminary conclusion, therefore, is that the oil and gas from the Shacan-2 well may have come primarily from Cambrian and Ordovician source strata.

The discovery of the Shacan-2 well has provided further confirmation of the vast prospects in the search for oil and gas in the Tarim Basin. However, differences in oil formation and geological conditions in the different structural components mean that the primary oil exploration targets are different for each region.

## I. Favorable Regions in the Search for Paleozoic Oil and Gas Pools

1. The Xayar uplift and its southern side. The Xayar uplift is bounded on the north by the Yakennan fracture and extends to the area near to Tarim He to the south. It joins the Kalpin uplift to the west and extends eastward to the Kuruktag uplift, covering a total area of about 30,000 square kilometers. According to aeromagnetic and gravity data, the Paleozoic is buried at 4 to 8 kilometers and the pre-Cambrian basement is buried at 6 to 9 kilometers.

This uplift appeared during the late Caledonian period and assumed a fixed shape during the late Hercynian. It was in an underground uplift state during the Mesozoic, and it lost the qualities of an uplift during the Cenozoic and became the slope of the northern side.

Three sets of oil-generating rock systems, the Cambrian-Ordovician, Carboniferous-Permian and Triassic-Jurassic systems, developed on the uplift. Moreover, it is located between the Kuqa depression and the Awat-Manjiaer depression and is a directional region of oil and gas migration. Reservoir rock was extremely developed in the uplift throughout all periods. Especially important are the carbonate rock strata at the top of the Cambrian-Ordovician systems that were exposed to weathering, filtering and corrosion for long periods. Secondary pores, holes and sutures are extremely developed. An examination of rock cores from the Shacan-2 well shows secondary pores and sutures that are usually about 1 mm wide, the large ones reaching 3 mm or more. There also are occasional solution holes as large as 6 mm across. Electron microscope measurements indicate that pores account for about 5 percent of the total area of the rock and that they are well-connected. The width of fissures is about 1 to 5  $\mu$ , while solution pores generally are about 5  $\mu$ , with the largest ones reaching 200  $\mu$ . Moreover, not only was there rapid progress during drilling in the dolomite at the Shacan-2 well, but the loss of vacuum in the drilling tools, the serious drilling mud leakage and other phenomena indicate that the uplift has excellent reservoir rock systems with large pores and high permeability in Cambrian-Ordovician dolomite, limestone and other rock.

Fractures also are fairly developed on the Xayar uplift. Seismic and gravity surveys have confirmed that there are more than 30 fractures in three groups with ENE, NE and NW orientations. Their active periods generally began during the late Hercynian and extended into the Miocene. These criss-crossed fractures played a role in improving the performance of reservoir strata, in providing oil and gas pools migration routes and in occluding and sheltering oil and gas. More than ten local structures or abnormalities have been found at the uplift and the area to the southern side that provide excellent conditions for oil and gas pools accumulation.

In summary, the region has excellent petroleum conditions and the target strata are at depths that can be reached with current drill rigs. It is the optimum and most practical region with prospects for finding large oil and gas pools.

2. The central uplift region. This runs across the central part of the basin and forms a Paleozoic-Mesozoic uplift region that spreads out in a NW direction. It has a sloping configuration that is high in the NW and low in the SE, and it is divided into the two secondary structural components of the Bachu uplift and the Katake uplift. The Paleozoic era is rather fully developed on the uplift and rich oil and gas indications have been found in the Carboniferous-Permian systems. The Paleozoic is buried at fairly shallow depths and there are surface outcrops in some locations. It is a favorable region in the search for Paleozoic oil and gas pools of different types.

3. The Markit slope. This is a large gentle slope formed during the late Paleozoic that is low in the southwest and high in the northeast that is overlapped by the Mesozoic and Cenozoic in steps moving from southwest to northeast. The Paleozoic is well-developed on the slope and is buried at rather shallow depths. Excellent oil and gas indications and a modicum of crude oil were seen in the Maican-1, Maican-2, Qu-1 and Qu-2 wells that already have been drilled there, indicating that the Paleozoic has excellent oil generation and reservoiring conditions. This makes this region a favorable one in the search for Paleozoic oil and gas pools. Special attention should be paid to the area near the Serikbuya fracture, the overlap positions of different eras, the unconformity at the top of the Paleozoic, and the lithologic and other traps that may have formed.

4. The Guchengxu slope (at the southern edge of the eastern Tarim depression) and the north Minfeng-Luobuzhuang fracture uplift. The northern part is the Shuntuoguole and Manjiaer depressions, while the southern part of the Qiemo fault subsidence, both of which are directional regions for oil and gas migration. The Paleozoic is completely developed on the Guchengxu slope and is buried at shallow depths. The Cenozoic may overlap the Paleozoic or Protozeroic at the north Minfeng-Luobuzhuang fault uplift. It is possible, therefore, that various types of oil and gas pools may have formed and that this is one of the favorable regions in the search for Paleozoic oil and gas pools.

## II. Favorable Regions in the Search for Mesozoic and Cenozoic Oil and Gas Pools

The prospects for finding oil in the Mesozoic and Cenozoic are extremely broad in the Tarim Basin. The reason is that not only do the Mesozoic and Cenozoic eras themselves have rather good oil and gas generation and reservoiring conditions, but also that oil and gas pools produced in the widely distributed Paleozoic may have migrated along fractures and unconformities into the Mesozoic and Cenozoic eras. This means that the oil sources are unusually adequate. Only suitable traps would be required to cause the formation of oil and gas pools.

1. The Yecheng-Yutian, Kashi, Manjiaer, Shuntuoguole, Kuqa, Awat, Qiemo and other depressions are favorable regions in the search for Mesozoic and Cenozoic oil and gas pools. At the Yecheng-Yutian depression, for example, the Kekyar oil and gas field already has been found, as has the Yiqikelike oil

pool in the Kuqa depression. Oil and gas flows also have been discovered at Kelatuo, Yangye and other sites, all of which are excellent examples.

In the search for region with Paleozoic oil and gas pools, we cannot ignore the search for Mesozoic and Cenozoic oil and gas pools. At the Shacan-2 well, for example, oil and gas indications already have been found in the Mesozoic and Cenozoic, and it is a new thread to follow.

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## OIL AND GAS

### REASONS FOR ACCELERATING OIL EXPLORATION IN TARIM ARGUED

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6, SPECIAL ISSUE, June 85 pp 53-54

[Article by Tian Zaiyi [3944 0961 5669], senior engineer, Beijing Petroleum Exploration and Development Research Institute: "The Tarim Basin Has Broad Oil and Gas Prospects, Exploration Should Be Accelerated"]

[Text] The Tarim Basin is the largest endocratonic garben downwarped composite basin in China. Its large area, thick sedimentary rock and many oil reservoiring structures provide rich indications of oil and gas, and it attracted the attention of petroleum geologists quite early. The desert cap that covers half the basin and the very poor natural and geographical conditions, however, have meant that all previous work has been done at the margins of the basin, so our understanding of objective geological bodies is subject to certain restrictions. We have gone into the middle of the desert in recent years to do large seismic profiling measurements and exploratory drilling work, and we have gradually come to understand many problems of petroleum geology. This is especially true of the high-output oil and gas flows that gushed from the Shacan-2 well at the depth of 5,391 meters. They opened a new realm for petroleum exploration in the Tarim Base, pointed out the direction for oil and gas prospecting and increasing our confidence in finding large oil pools.

Surface strata outcrops at the margins of the basin and analysis of geo-physical data indicate that the basin's structures have an obvious phase quality of moving from activity to stability and then to renewed activity. The Archaeozoic and Protozeroic eras are deeply metamorphized volcanic rock and moderately to slightly metamorphized clastic rock, mainly carbonate rock, and were the phase of platform basement formation. The sinian to Paleozoic eras are stable platform sediment clastic rock, mainly carbonate rock, and they are the phase of sedimentary platform capping strata. The thickest lower Paleozoic sediments, about 10,000 meters, are found in the Awat-Manjiaer depression. The thickest upper Paleozoic sediments, about 5,000 meters, are found in the area of Kashi-Yecheng in the western part of the platform. The structure and thickness of such accumulations indicate a deepwater facies water environment, and all of them were conducive to the formation of parent material for oil generation. The basin was uplifted from the Triassic to Tertiary eras, which was the phase of a Mesozoic and

Cenozoic fault-sage continental facies sedimentary basin. The Triassic-Jurassic period was one of fault subsidence, the Cretaceous-early Tertiary was a period of fault-sag, the upper Tertiary was a period of a unified depression, and the basin shrank during the Quarternary. Himalayan orogeny and the intense uplifting of the Qinghai-Xizang Plateau in combination with intense fracturing activity at the boundaries of the basin caused the basin as a whole to subside. The differential activity of the block faults was apparently extremely intense. This gave the basin the characteristics of rapid sedimentation, intense changes in lithology, coarse sedimentary material, thick accumulations and migration of the center of the subsidence. The Triassic system is distributed over an area of about 180,000 square kilometers in the Awat-Manjiaer depression and the Kuqa depression. Apart from the Jurassic that succeeded the Tertiary sediments in the eastern part of the basin, a new fault-sag developed in the Kashi-Yecheng area and accumulated very thick material. Most of the Tertiary and Jurassic sediments were dark clastic rock, which is an excellent parent material for oil and gas generation. During the late Cretaceous to early Tertiary periods, the ancient Tethys seawater entered the Kashi-Yecheng region in the western part of the basin through the Alai Sea gorge and developed rather good sea-land interchange facies strata. The two sedimentation centers at Wupoer and Yecheng are zones conducive to oil generation. Rather thick upper Tertiary dark argillaceous rock accumulated in the area of Wuqia, which also has abundant parent material for oil generation.

The Tarim Basin is a relatively stable geodesic structural component located between the Tian Shan geosyncline and the Kunlun Shan geosyncline. There are outcrops of basement rock strata and Paleozoic sedimentary capping strata in the mountain ridges around the perimeter of the basin. Most of the central part of the basin is capped by enormously thick Mesozoic and Cenozoic strata. Based on revelations from well drilling, linked well seismic profiles, the thickness of the strata of each period and their depth of burial and distributional conditions, and starting with the concepts of petroleum geology for comprehensive analysis, the basin can be divided into 11 secondary structural components: the central [Bachu] uplift, the Awat-Manjiaer depression, the northern Tarim [Xayar] uplift, the Kuqa depression, the Kashi-Yecheng depression, the Qiemo fault uplift, the Ruoqiang fault uplift, the Kuruktag fault uplift, the Kalpin fault uplift, the Tekiliktag fault uplift and the Altun Shan fault uplift. The first seven structural components are located within the interior of the basin and the target strata are buried deep underground. All of them have oil and gas prospects and are new realms of exploration. The four latter structural components have been in an uplifted denudation geological environment for a long time. The process of crustal movement and the associated intense volcanic activity did not provide conditions conducive to oil formation and there were rather poor preservation conditions, so there are no prospects for oil and gas there.

Understand sources and practice. During the process of petroleum exploration in China, we have understood the geological conditions of oil and gas pool formation to be: First of all, there must be an abundance of parent material for oil generation, and the development of oil generating rock is the most fundamental condition among the factors affecting the prospects for oil and

gas. Second, there must be excellent reservoir strata. The wider their distribution, the greater the degree of oil pool richness. Third, the formation of traps is indispensable, and there should be an excellent matching relationship between hydrocarbon formation, migration and accumulation and the formation of structures. The preceding interpretations indicate that the Tarim Basin is one of the most promising regions on the Chinese continent. In addition, it is best if an evaluation of the structural components of the Tarim Basin begins with the northern Tarim uplift. The focus at first should be on exploration and comprehensive dissection to achieve breakthroughs at the earliest possible date. Second, work should be developed actively in the Kuqa and Awat-Manjiaer depressions to search for primary oil pools in deep strata and secondary oil pools in shallow strata. Sufficient attention should be paid to investigations in the central uplift and the Awat-Manjiaer depression.

I now will refer to the seismic structural maps drawn by Comrade Chai Guilin [2693 2710 2651] and provide some additional views concerning the northern Tarim uplift.

The northern Tarim uplift is located between the Kuqa depression and the Awat-Manjiaer depression. It extends from Ketuer to the west to Korla in the east, and is bounded by Taken on the north and the Tarim He on the south, covering an area of about 18,000 square kilometers. The deep depressions on either side of the uplift had oil generating sedimentary environments during different eras and provide rich sources. The Cambrian system has dark shale and bituminous limestone, the Ordovician system has black marl and carbonaceous shale, and the Carboniferous system has dark colored mudstone and pelitic limestone. All of them have a certain oil generation capacity. The area was an underwater uplift during the Triassic-Jurassic period and thick dark-colored mudstone sediments accumulated in the depression on either side. There was rich oil generation material and adequate oil sources. This uplift was uplifted continuously over a long period of time, which is conducive to oil and gas migration and rich accumulation. A large platform anticline zone already had formed by the time of the Caledonian orogeny cycle. It was further strengthened during the Hercynian cycle, which created a series of fracture zones running parallel to the uplift that are oil and gas migration paths. Rather thin Mesozoic strata developed on top of the uplift, while the lower Tertiary sediments are absent. During the upper Tertiary, it becomes a regional slope inclined to the north. Regional unconformities and stratigraphic overlaps were formed during many periods on the uplift, all of which may have served as oil and gas migration routes. In addition, the unconformities were subjected to long periods of weathering and filtering during the cycles of activity, which many have created excellent reservoir spaces. The leakage of drilling mud and loss of drill vacuum at the Shacan-2 well, for example, is sufficient proof. Current seismic information indicates that many types of trap structures exist. Examples include the local traps at Yakela, Erbatai, Luntai, Kuqa, Tiergen, Luntainan, Yingmaili, Qongkol and other places. There are also structural traps in the footwalls over reverse thrust faults, fault sheltered traps, unconformity traps, and so on. During key exploration and comprehensive dissection, we should act as if we were dissecting Daqing and Changheng to make comprehensive deployments and use

three-dimensional seismic methods to carry out large profile measurements. In addition, we should drill pre-exploration wells in structures such as those at Erbatai, Luntai, Tiergen, Qongkol, Dayouerdusi, Yingmaili and other places, and seismic profiles should be joined up with well drilling. Good work should be done in using synthetic acoustic measurements of sound velocities in the wells and rock, offset and superposition and seismic stratigraphy interpretation work. If we begin here, further deployments can be made on the basis of preliminary exploration and research results.

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## OIL AND GAS

### PETROLEUM POTENTIAL OF THE NORTH TARIM BASIN OUTLINED

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6, SPECIAL ISSUE, Jun 85 pp 55-56

[Article by Ya Xiugang [7051 4423 0474], chief engineer, Comprehensive Petroleum Geology Brigade, Ministry of Geology and Mineral Resources: "Examining the Oil and Gas Prospects of the North Tarim Basin"]

[Text] The flow of oil and gas from the Shacan-2 well and Kekyar indicate that it does not matter whether one thinks of the regional structural components of the Tarim Basin as "one uplift and two depressions" or "three uplifts and four depressions" because all of the structural components should contain oil and gas resources to different degrees. Furthermore, the prospects are considerable and we should harbor no doubts.

The gusher at the Shacan-2 well certainly was no accident. Actually, it was inevitable. What was accidental was the inadequate forecast of the ability of such a large flow of oil and gas to erupt from the lower Paleozoic. This question had not received sufficient attention even up to the point where leakage was discovered when the drill passed through the top of the eroded surface. This shows that our ideas were not sufficiently open.

There is little possibility that the oil at the Yakela structure came from the Triassic-Jurassic systems. The basis for this conclusion is that the Triassic-Jurassic oil generating rock encountered during drilling at the Yuecan-1, Acan-1 and Shacan-1 wells in the northern Tarim region was not very developed, and there was quite a bit of absence or erosion. In addition, there is an eroded surface above, but no obvious indications of oil and gas were seen. The sporo-pollen fossils contained in the Triassic-Jurassic crude oil apparently are related to the Luoyan well section of the Triassic-Jurassic at the bottom of the well. We cannot overlook oil coming from the Carboniferous system, and natural gas may have been formed in upper Sinian-lower Cambrian parent rock.

Analysis of the seismic 302 line profile indicates that the Shacan-2 well is not located at the top of the ancient uplift, but instead is located on the southern slope of the E-W oriented ancient uplift. The high point at the west of the Yakela structure, nevertheless, is an anomaly caused by differences in seismic wave velocity and there is only a minute uplift in the  $T_5^0$

wave group. Calculations of the depth at which the uplift is buried, however, indicates that it is buried at more shallow depths than the top of the ancient uplift, so we can infer that this uplift is due to the effects of the ancient terrain. The modern oil and gas gushers are located on the southern side of the ancient Xayar uplift, the western part of the Yakela structure and in epsilon-shaped oil and gas traps formed in residual dolomite under the ancient regional eroded surface, so there is a high degree of rich oil and gas accumulation. This type of oil and gas trap has two main characteristics. One is that it often is associated with other types of oil and gas traps. The other is that there is a high degree of rich accumulation but the reservoir area is not very large. The former has awakened us to the need to search for other types of oil and gas in this region, while the latter has shown that too-great distances between wells might drill outside of the petroliferous area and produce water.

It was felt at first that the southern side of the ancient uplift was the oil source of the Shacan-2 well and that the oil and gas had migrated laterally to accumulate richly at the upper wall of the reverse fault on the slope at the southern limb of the ancient Xayar uplift. The reason is that structural position of the Shacan-2 well as shown on the above-mentioned seismic 302 line moving downward from the regional eroded surface to the top of the Protozeroic metamorphic rock would permit only a 1,000 meter rock layer to be contained there. There has been no determination of lower Paleozoic-Sinian oil generating rock to date and there are many intermediate absences and erosions. Although there may be oil generating rock, it would be hard for its total generation capacity to reach the daily output level of 1,000 tons of oil and 2 million cubic meters of natural gas. We cannot, therefore, envisage that the oil source arose from lateral migration.

It can be seen from regional geological data that the ancient Xayar uplift is the key area and that a type of warped plate activity appeared on the southern and northern sides during the process of Paleozoic and Mesozoic sedimentation, causing the oil and gas pools formed during different periods to migrate in the direction of the ancient uplift. This is a superior pattern for an oil and gas accumulation zone. Two main oil and gas accumulation zones of this type can be found in the northern Tarim region, and these can be divided into four sub-zones. All of them may be excellent zones for oil and gas accumulation.

After the key breakthrough of oil flows during the first phase of petroleum survey and exploration work, the second phase is first of all to determine if there really are oil and gas accumulation zones here. How have these structures developed? What about the oil-bearing area and the degree of rich accumulation? The adjoining depression regions and the ancient uplift itself have several sets of reliable oil generating rock. What is their distribution and thickness? For these purposes, petroleum survey and exploration work during the present stage should be developed in a regional manner. Concentration on a single corner could lead to "haste making waste."

The Shacan-2 well should be made the nucleus of the Yakela structure, and we should strive to locate an oil-bearing area as soon as possible, submit specific geological reserves and make good preparations for development.

If these two areas can be integrated well, then they will be able to promote surveys, exploration and development of this place. If they are dealt with poorly, it will affect the pace of progress in survey and exploration.

The Shacan-2 well gusher is no less important than a gold medal in the Olympics. Like the young ladies of the women's volleyball team, the geological exploration personnel who are struggling on this front line should be commended and rewarded, and we also should not forget those "nameless heroes" who have gone before us.

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## OIL AND GAS

### OPINIONS ON PETROLEUM EXPLORATION IN TARIM BASIN PRESENTED

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6,  
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[Article by Chai Guilin [2693 2710 2651], chief engineer, Geophysical Exploration Bureau, Ministry of Petroleum Industry: "Some Views Concerning the Search for Oil in the Tarim Basin"]

[Text] The geophysical Exploration Bureau has done a great deal of work involving seismic, gravity, geodesic electromagnetic depth measurements and other types of comprehensive exploration in the central desert region, northern Tarim region and Baicheng Shan region in recent years, and we have obtained rich information. Preliminary processing of these data will be used to provide some individual views concerning oil exploration work in this region.

#### I. The Manjiaer Depression is a Polycyclic Oil-Generating Depression, and the Perimeter of the Depression Is a Favorable Region in the Search for Large Zones of Rich Oil and Gas Accumulations

The latest seismic results indicate that there is a Paleozoic and Mesozoic deep depression in the Manjiaer region, and that it is mainly the lower Paleozoic (possibly including the Sinian system) and reaches a maximum thickness of 8,000 to 9,000 meters at Manjiaer. The Jurassic-Triassic depression center moved eastward to the west side of Yingjisu and has a maximum thickness of 2,500 meters. New seismic results also indicate that the Carboniferous and Permian systems are distributed widely in the eastern part of the Tarim Basin and reach a maximum thickness of 2,000 meters. The Jurassic-Triassic and Carboniferous systems are considered the primary oil generating strata in the Tarim Basin. Very little work has been done on the lower Paleozoic, but surface outcrops suggest that it is dark argillaceous rock, bituminous limestone and dolomite and that it has a certain oil generation capacity. This is especially true of the Shacan-2 well, where analysis of the oil, gas and water permits us to infer that the oil source may have been marine facies strata. I feel that, besides the Carboniferous, it may have come from the lower Palozoic. For this reason, the Manjiaer depression with its enormously thick lower Paleozoic should attract sufficient attention from us in the search for oil and gas.

## II. The Eastern Part of the Central Uplift Is a Lower Paleozoic Large Uplift Zone and a Favorable Region in the Search for Lower Paleozoic Primary Crude Oil Pools

The central uplift is divided into east and west sections by the Yutian He. The western section is a fault-uplift (the Bachu fault-uplift) that was formed during the Yanshanian and Himalayan periods. The eastern section is a large uplift zone (the low eastern uplift) formed by the Caledonian orogeny. The low eastern uplift was in a stable state continuously following the early Paleozoic. The upper Paleozoic, Mesozoic and Cenozoic eras all overlap the top of the uplift in the form of monoclines and thin out, forming the special "dual strata structure" found in the eastern region. Current information indicates that the uplift extends to the east and joins gradually with the Minfeng-Qiemo uplift in the vicinity of Qiemo. Fault contacts lie between them. The central uplift region covers an area of nearly 70,000 square kilometers. The Cenozoic is rather thin on top of the uplift, usually about 2,000 meters. The Mesozoic is absent. The Neogene overlaps directly on top of the Carboniferous and Permian systems.

The northern side of the low eastern uplift lies near the Manjiaer depression. The structure was formed early and is completely preserved. The layout of oil and gas formation and migration relationships is good, and it is an unusually ideal region in the search for lower Paleozoic primary oil and gas pools.

## III. The Northern Tarim [Xayar] Uplift Is a Large Oil and Gas Rich Accumulation Zone With Many Types of Traps and Target Strata Systems

The uplift is bounded on the west by Karayulgun and the Ketuer fault, on the east by Korla, on the south by the Luntai fault and on the north by Qiulitai and the Yaken anticline. It covers a total area of about 17,000 square kilometers. The Geophysical Exploration Bureau has completed nearly 5,000 miles of seismic measurement lines to date. The northern Tarim uplift can be divided into three sections. The western section is the Yakela-Luntai structural zone. The middle section is the Yakela-Luntai structural zone. The eastern section is the Korla nose-uplift zone. The northern Tarim uplift was formed during the Caledonian period. It was strengthened during the Hercynian period and formed a series of reverse thrust faults. The Mesozoic sediments first were subjected to intense erosion and smoothing. The Paleozoic is absent at the top of the uplift zone and the Mesozoic overlaps the Protozoic. This is most prominent in the middle and eastern sections. It was stabilized gradually after the Hercynian and there was a tendency toward its elimination during the Miocene, when it became the southern slope of the Baicheng depression.

The northern Tarim uplift is located between the Baicheng depression and Manjiaer depression, so it has rich oil sources. The multiple periods of structural activity during the Paleozoic, Mesozoic and Cenozoic caused the formation of developed local structures and multiple types of traps. More than the ten local structures already have been found, with traps covering a total area of more than 1,000 square kilometers. Besides structural traps, buried hill traps, it also saw the formation of stratigraphic unconformity

traps, fault traps, overlap unconformity traps and lithologic traps. Comprehensive analysis of the positions of regional structures there, the occurrence and evolutionary characteristics of the structures and other aspects indicates that the northern Tarim uplift is a large zone of rich oil and gas accumulation with multiple types of traps and multiple target strata systems.

#### IV. Large Gentle Structures Exist Under the Sloping Structure at the North of the Baicheng Depression.

The Baicheng depression is a Mesozoic-Cenozoic Tian Shan premontane depression. Intense compression from the Tian Shan folded zone caused the surface structures to incline and move closer, and faults developed. No major breakthroughs have been made to date despite the fact that exploration began in the 1950's. One of the reasons is a lack of conformity between the structures above and below and the lack of a clear understanding of deep structures. The Bureau began using controllable seismic sources here for exploration in 1983 and the results have been extremely apparent. We discovered that the upper and lower structures at the Kumukeliemu and Kasangtuokai structures were two body systems, and that the Cenozoic contains complex surface folding. The top surface of the Mesozoic is a gentle and simple large anticline. The axis of the anticline is located in the synclinal position between Kumukeliemu and Kasangtuokai. The top of the anticline covers an area of more than 10 square kilometers and now controls an area of more than 400 square kilometers. The Mesozoic in the Baicheng depression has excellent oil generation conditions and there is hope that large high output oil and gas pools will be found once the regularities in changes in the upper and lower structures are understood clearly.

#### V. Some Views Concerning Acceleration of Oil and Gas Exploration Work in the Tarim Basin

1. The northern Tarim region. We should continue to expand our achievements on the basis of the Shacan-2 well in the northern Tarim region. The overall principle is to make an attack on the central section and swing to the east and west, and to select different structures, different locations and different types of traps for exploratory drilling to derive a comprehensive dissection of the northern Tarim uplift.

The fact that Cenozoic era on the northern Tarim uplift is very thick means that making the Paleozoic the only target of exploration will require large investments and long time periods, which is not favorable for accelerating oil and gas exploration in Tarim. Therefore, in addition to searching for Paleozoic carbonate rock high output oil and gas pools, we also should study nearby oil sources and the conditions of traps adjacent to faults to search for secondary oil and gas pools at rather shallow depths.

In the area of types of traps, the intense erosion and smoothing that followed the Hercynian period meant that the unconformity at the top surface of the Paleozoic is rather gentle and has a very small range.

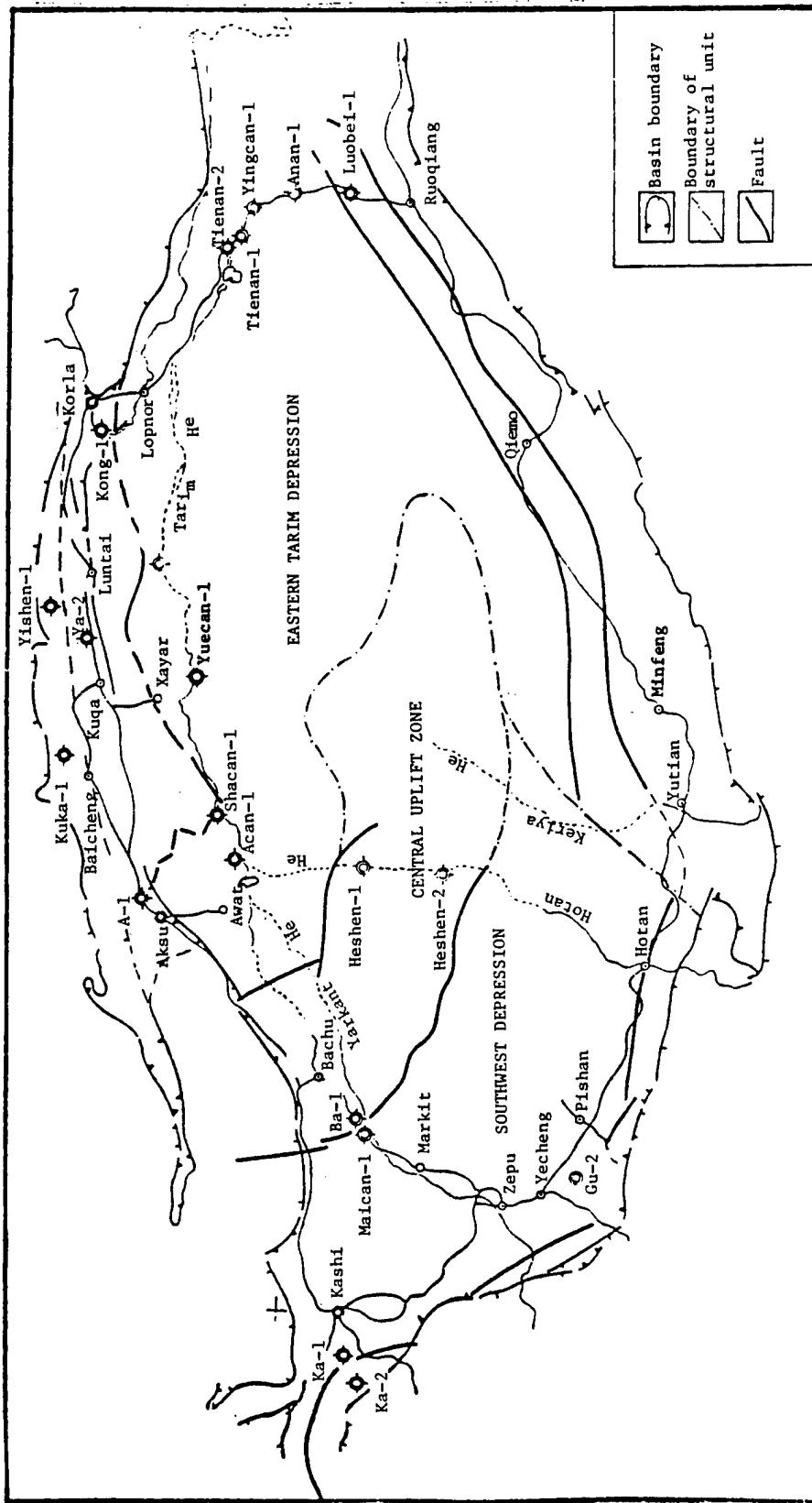
The scale of buried hill oil and gas pools is rather small. For this reason, we should pay special attention to unconformity traps in strata below the

unconformity since this type of trap occurs on a large scale. To achieve this, we must abandon conventional structural mapping methods and compile maps that integrate the unconformity with the strata below.

Exploratory drilling should be done first in the southern Karayulgun concealed structure, south of Dayoudusi, Yingmaili, Yakelache, Luntai, Tiergen on the southern side of Qedir and the nappe at the downthrown side of the Lunnan [south Luntai] fault.

The low eastern uplift. Although the low eastern uplift of the central uplift has very good oil and gas conditions, the area is located in the ventral part of the desert. Natural conditions are poor and work is difficult. In addition to strengthening seismic exploration at the present time, we can drill two parameter wells to the west of Argan and prepare the conditions for the next step in comprehensive exploration.

3. The Baicheng depression. Drill two exploratory wells in the large structure that was discovered using seismic methods in the northern part and penetrate to the Tertiary to understand the oil and gas conditions of the Mesozoic.
4. The Qongkol structure to the south of Yuli. Deploy one well to understand the oil and gas conditions of the Mesozoic and Paleozoic.
5. Research work. We should strengthen research on lower Paleozoic oil generation conditions to derive a correct evaluation of lower Paleozoic oil and gas resources.



Structural Divisions of the Tarim Basin

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